

Mohamed Eldishnawy

## **Adapting Open Innovation in Information and Communications Technology Ecosystem Dynamics**

### **School of Electrical Engineering**

Thesis submitted in partial fulfillment of the requirements for the degree of Master of  
Science in Engineering

**Supervisor:**

Docent Kalevi Kilkki

**Instructor:**

Docent Kalevi Kilkki

*"Do not sleep on hatred, and do not wake up on desire. Do not seek to greed, and do not race for authority and power. But let your concern and interest in the goodness, righteousness, truth and honestly, chivalry and aid. Seeking only eternal acceptance"*

Songs of sins and innocence, Dr. Mustafa Mahmoud

*"If a believer and an unbeliever dive into the sea, only that learned how to swim survives, God do not favor an ignorant. The fool believer will sink, and the wise unbeliever will survive"*

Unknown, Dr. Mustafa Mahmoud

Author: Mohamed Eldishnawy		
Title: Adapting Open Innovation in ICT Ecosystem Dynamics		
Date: 28.6.2013	Language: English	Number of pages: 73
Department of Communications and Networking		
Professorship: Network Economics		Code: ETA3003
Supervisor: Docent Kalevi Kilkki		
Instructors: Docent Kalevi Kilkki		
<p>The current ICT (Information and Communications Technology) industry became robust and highly competitive. This is due to the shorter life cycle of products and the increasing demand of people in the current connected world. Thus, having an accelerated innovation system became a strategic need for firms to strive and lead. Many firms tried to accelerate their innovation process by collaborating with external players, or by proceeding internal changes, still a challenge exists in the need for an organized open innovation process that leverage external resources, while fitting within the firm own strategy and internal resources. The existing work and research in open innovation focuses more in managerial, legal and behavioral aspects in innovation process. Although all these aspects are essential, the real challenge is in the dynamics between the different factors and acting elements in the innovation process. Therefore, the focus of this study is to explore the dynamics of open innovation. The research was done based on the interviews conducted and literature review. The thesis will propose a system dynamics model for open innovation. In addition, it will study the effect of open innovation on firms, specifically that in ICT industry. Furthermore, it will explore the different phenomena and opportunities resulting from adapting open innovation.</p>		
Keywords: Open innovation, System Dynamics, innovation phenomena, long-tail		

## **Preface**

This Master's Thesis has been written as a partial fulfillment for the Master of Science Degree at Aalto University, School of Electrical Engineering. The work was carried out in the Department of Communications and Networking, majoring in network economics research field, and as a part of the human-centric research group led by Docent Kalevi Kilkki.

I wish to express my gratitude to the people who have supported me in this work. First of all, I wish to thank Docent Kalevi Kilkki for providing the opportunity to write this thesis under his guidance. I am especially grateful to the experienced interviewees from different firms and organizations that dedicated part of their time and knowledge to finish this study, in specific, many thanks to the following: Elisa Oyj, Nokia Siemens Network, Ericsson and Aalto University represented in Aalto Design Factory.

Last but not least, I wish to address my gratitude to my family for their support during the course of my studies in all means, and I wish them happiness and health in their life. Special thanks to the closest people and my dearest friends for their moral support during the hard times, specially my beloved ones.

And finally and above all, thanks to God (Allah) for his patience, mentoring and setting my mind in the right path during the last 2 years and in my whole life.

Espoo, 26<sup>th</sup> June 2013

Mohamed Eldishnawy

## Table of Contents

Preface .....	iii
Table of Contents.....	iv
List of Figures.....	vi
List of Tables .....	vii
Acronyms.....	viii
Chapter 1: Introduction .....	1
Chapter 2: Background.....	4
2.1    Importance of Innovation .....	4
2.2    Introduction of open innovation.....	5
2.3    Henry Chesbrough's Research .....	6
2.3.1    Closed innovation .....	7
2.3.2    Open innovation.....	9
2.4    Open innovation and business modeling.....	12
2.5    Towards open innovation standardization .....	14
Chapter 3: Methodology.....	17
3.1    First Method: Interviews.....	17
3.2    Second Method: System Dynamics.....	18
3.3    Third Methods: Open innovation business aspects.....	21
3.3.1    Areas of interest of open innovation.....	21
3.3.2    The long-tail business model .....	23
Chapter 4: Interviews and case studies .....	25
4.1    Interviews Results .....	28
4.1.1    Perception of Open Innovation .....	28
4.1.2    What delays innovation? .....	29
4.1.3    What foster innovation?.....	30
Chapter 5: Analysis .....	32
5.1    Dynamics in open innovation.....	32
5.1.1    Innovation dynamics.....	32
5.1.2    Open innovation system dynamics model.....	34

5.1.3	Causal Loops.....	43
5.2	Open innovation in business .....	48
5.2.1	Business approach in innovation .....	48
5.2.2	The long-tail phenomenon.....	50
5.3	Future in ICT .....	52
Chapter 6: Conclusion.....		54
6.1	Key Findings.....	54
6.2	Future Research.....	55
References.....		56
Appendix.....		62

## List of Figures

Figure 1: The innovation Funnel (adapted from GA Stevens) .....	5
Figure 2: Closed innovation (adapted from Henry Chesbrough) .....	8
Figure 3: Existing innovation appraochs utilized by firms .....	10
Figure 4: Open innovation model (adapted from Henry Chesbrough) .....	11
Figure 5: Nambisan innovation business models .....	13
Figure 6: Chicken road-crossing system dynamics model .....	19
Figure 7: Advanced Chicken road-crossing system dynamics model .....	20
Figure 8: Areas of interest of open innovation model.....	21
Figure 9: Long-tail business model .....	23
Figure 10: Industry-level system dynamics model .....	33
Figure 11: System dynamics model Of Open Innovation .....	34
Figure 12: Introducing new knowledge system dynamics model.....	35
Figure 13: Absorption Capacity .....	36
Figure 14: Developing ideas system dynamics model .....	38
Figure 15: Commercializing ideas system dynamics model.....	39
Figure 16: Product success system dynamics model .....	43
Figure 17: Knowledge creational loop .....	44
Figure 18: Knowledge network loop .....	44
Figure 19: Development network loop .....	45
Figure 20 Market Initialization loop .....	46
Figure 21 Customer Loyalty loop .....	46
Figure 22 Detailed Open innovation system dynamics model .....	47
Figure 23: Current ICT players' areas of interest of open innovation .....	49
Figure 24: Idea posting distribution long-tail curve (adapted from Novozymes) ...	50
Figure 25: Global smartphone market share – based on Gartner and IDC .....	51
Figure 26: Revenue per App Rank (Adapted from Ferry Analytics) .....	52

## List of Tables

Table 1: Difference between closed and open innovation .....	9
Table 2: Nambisan network centric innovation principle.....	13
Table 3: Comparison of four different types of openness (Dahlander <i>et al.</i> ) .....	16
Table 4: Interviewees .....	27



## Acronyms

OI	Open innovation
ICT	Information and Communications Technology
OS	Operating System
SME	Small-medium sized enterprises
R1	Rate of introducing new ideas into the firm
R2	Rate of developing ideas
R3	Rate of commercializing and marketing the idea
R4	Product Adoption rate
R5	Product Discard rate
R&D	Research and Development
NRC	Nokia Research Center
NSN	Nokia Siemens Networks
PARC	Palo Alto Research Center
ICC	Idea Implementation Capacity
PDP	Product Development Project
P	Proactive loop
R	Reactive loop

## Chapter 1: Introduction

Innovation has recently been realized to be the main driver for firms to thrive, grow and sustain high profitability [1] [2]. This makes innovation a strategic need for firms competing in an industry. Innovation thinking originated from more than 30 years ago. Early researchers, such as Michael Porter, identified innovation as the internal R&D (Research and Development) of a company. Porter advised firms to heavily invest in R&D, thus creating a differentiation factor [3]. Consequently, most companies began to invest in R&D centers and divisions. Bell Laboratories of AT&T is one example. Such previously discussed vertically integrated and inward innovation approach was termed “Closed innovation” by Henry Chesbrough, who is known as “the father of Open innovation”. The term open innovation is centered on firms’ adoption of external ideas and technologies in their own innovation activities. At the same time, firms allow unused or under-used ideas to be exploited by other firms. Such a new approach in innovation led to the formation of a web of innovation between different players. Small-medium sized enterprises (SME) and new startups now can play a significant role in that web, thus resulting in the rise of new players. With the dexterous innovation adopted in the SME, incumbent companies started to collaborate with such small, skilled and agile participants for the overall benefit of their strategy. As a result of these strategic changes, the paradigm of innovation has been widened, thereby leading to an increase in competition. With such fertile land to innovate, having a competitive advantage became challenging, in fact, the old model of secrecy and internal R&D and patents became inoperative.

Since 1990, information diffusion in the innovation process dramatically increased due to the development of technology and society that enabled new sources of information, and different methods to gather and analyze it. For instance, in the mobile phone industry, rapid innovation became demanding, due to the shift of the mobile phone from being a normal handset to a smartphone. This dramatic increase in diffusion of information resulted in a decrease in the efficiency of the closed technology development models applied in the ICT (information and communications technology) industry. The need of a new way to innovate in technology started to

arise. Defining technology as the knowledge used to solve our problems and pursue our goals [4], assign technology innovation the creation of a new knowledge that can be applied to a certain problem. This application might have consequences that should aid in solving problems.

It became a must for the different players in ICT ecosystem to start adopting a more open innovative model replacing the deficient closed existing models. Innovation currently has its strategic reasoning and need in the ICT ecosystem. Various market changes led to such a need, for instance, the shortened product life cycle, which is the time it takes the product to be obsolete or replaced by next-generation of product. For mobile phones, including smart phones, life cycle varies between 12 to 24 months [5]. As a result, a firm whose innovation process is slow or that lacks disruptive innovative environment, loses market to the other competitors. Hence, innovation acts as a strategic imperative for firms.

As elucidated above, innovation is not a new concept; research done on innovation by Porter, Allan and other gurus had been the seed for innovation studies. Afterward, the introduction of open innovation by Chesbrough and other gurus explored a new paradigm of research related to innovation. In the case of ICT industry, research in open innovation extends and explores many fields, including revealing internal resources to external environment [6], out-licensing or selling products [7]. The areas of research extends to take into account the acquisition of inventions, introducing the innovation process of firms, through informal and formal relationships [8], and other aspects. However, such researches have focused more on behavioral, managerial and legal aspects of open innovation. As a result, it had minimal focus on the dynamics in innovation process with few explorations of the dynamics between different variables that forms the success of innovation process. Thus previous researches have adapted a more static approach towards studying open innovation.

The purpose of this study is to introduce a new approach to model open innovation constitutional functions and variables, taking into consideration both static and dynamic view of open innovation. The foundation of the study is inspired by Chesbrough's conceptualization of innovation [9]. To realize the dynamic perspective, the study will propose a model of different elements that are active during innovation

process. These elements will be utilized based on a research review that covers methods to create, develop and monitor the innovation process. In addition, the study will explore as well the phenomena associated with open innovation from the business aspects.

The study is divided into six main chapters including Chapter One as Introduction. Chapter two discusses the background of the study. Open innovation will be defined by reviewing different research performed in that topic. Chapter three discusses the methodologies used in analyzing and modeling open innovation. Chapter four reviews the semi-structured interviews conducted with company representatives from different players in the ICT ecosystem. The chapter will describe the interviews and aggregate the information gathered through these interviews. The chapter will end with the results and outcomes from the interviews. Chapter five introduces the main analysis of the study in open innovation based on the previous chapters. The beginning of the chapter discusses the dynamics in open innovation. Later, it will explore various elements in open innovation and their roles. Based on this exploration, the chapter will discuss the open innovation system dynamics model developed in that study. In addition, the chapter will realize the business phenomena linked to open innovation. Finally, the chapter will deliberate examples of existing open innovation in ICT industry and the impact of adapting open innovation in the future of the industry. The final Chapter six will summarize the discussed topics in the study and research outcomes. The chapter ends with recommendations for future research in the topic of open innovation.

## **Chapter 2: Background**

In this chapter open innovation will be defined by reviewing different research done in that topic. The chapter will prepare the reader for the following chapters and will create a ground base for the study.

### **2.1 Importance of Innovation**

The importance of innovation arises from the globalization of markets. The thrill to foster technological innovation is driven by innovations acting as a competitive advantage. Due to the globalization, cross-borders competitors put pressure on firms to create a differentiated products and innovations. Innovation can be taken from two approaches: product innovation and process innovation. The first one helps protecting firm's competitive margin, while the second introduce the economies of scale and lowering costs effects. Advancements in information technology led to the creation of computer-aided tools that firms can use to speed their production and design processes. With the flexibility introduced with IT the cost of production became lower and higher efficiency. Such changes lead to a more differentiating power. Taking a view on the mobile market, Nokia – for example - offered almost 80 models of mobile phones. Such vast portfolios enabled Nokia to penetrate and reach almost all market niches, thus raising the bar of competition. This created a need for competitors to shorten development cycles and products' time-to-market in the mobile industry. All these rapid change in the industry led to accelerating the need of innovation, thus having innovation as a strategic presence for firms. Nowadays slow innovation process means losing the market.

Innovation process can be visualized by the “Innovation Funnel” shown in Figure 1. Most innovative ideas don't end up being a successful product or part of a successful product. This is due to the fact that an idea could be good enough but not technically feasible, or even if it was, it might fail to gain commercial return. A study done over innovation success rates and data on patents, venture capital funding and some other methods show that it requires 3000 raw ideas to get a final commercial successful product [10].

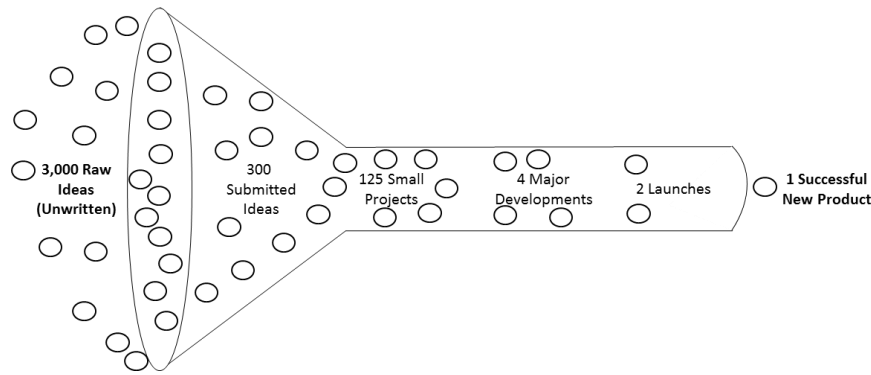


Figure 1: The innovation Funnel (adapted from GA Stevens)

Based on that performance firms try to study carefully innovation process from a strategic point of view, aiming towards increasing the success rate. Firm's resources and objectives must fit within the innovation process without affecting it. For a firm to adapt innovation and reach its ultimate goal, thus maximizing successful projects (technically and commercially), it must keep an in-depth understanding with the existing dynamics of innovation, a firm have to design innovation processes that implement innovation strategy, that should be a fitting with the overall firm strategy.

## 2.2 Introduction of open innovation

Since the more ideas the more possibility of creating a new innovative product, companies started to try to find other sources for ideas. Collaboration with research institutes and universities, and other source of business to business collaboration started to appear. The collaboration extended not only in the phase of idea generation but also in all the phases of innovation process. A clear example of that in the mobile industry is open source operating system (OS). Four out of the top six smartphone OS (iPhone OS, Symbian OS, Android/Linux, Palm WebOS, RIM Blackberry OS) are open source platforms with some limitations, especially for RIM and Microsoft Windows mobile OS which have strict proprietary rules. The dominating player now Android is a mobile OS based on Linux open source interface. The acceptance of Android as launched by Google November 2007, and its openness encouraged the developers and consumers to adapt to its introduction in the market. Android as the most open source mobile OS currently exists is a successful story of open source based ecosystem of mobile industry.

Although open source is a clear example of open innovation, it is still one of the open innovation paradigms that will be discussed later. Open design and Open standard for instance is other paradigms in open innovation. In fact open source was recognized and adapted before the introduction of open innovation broad concept. The publicity of open source was at 1998 Open source summit thanks to Linux operating system as the most successful story. Since that time open source referred usually to open source software, although practically it could refer to even non-software activities. Overall, open source did show that openness and collaboration leads to greater outcomes.

It was not before 2003 when the father of open innovation, Henry Chesbrough, developed the name of Open Innovation. Henry Chesbrough identified the previous adapted innovation processes that exemplified by Figure 1. He then named these innovation processes as closed innovation processes. Later analyzed the existing open innovation enabler processes like the one discussed in the previous example about open source triggered innovations. Henry Chesbrough differentiated between Open innovation and Closed innovation: Open innovation means that valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well”, Chesbrough then further describes the implications of closed innovation approach: Companies generate their own ideas and then develop them, build them, market them, distribute them, service them, finance them, and support them on their own [9].

Since then open innovation concept became a research area of interest to many firms and research institutions. Research is done to model open innovation, techniques on adapting open innovation and the effect of adapting open innovation on firms and the whole industry.

### **2.3 Henry Chesbrough's Research**

Henry Chesbrough divided innovation in firms into two approaches: closed and open innovation. The adaption of closed innovation approach means that any idea has to exploit existing firm capabilities of infrastructure and employees, if these capabilities not enough to move the idea from concept phase to product phase, then

the introduction of such idea to the market needs to be delayed till new supporting systems from marketing, production lines, distribution facilities or services either built or acquired and integrated. Adding to that some other firms might have another idea that is not fitting within their scope, or have a poor fit with their internal aptitudes and systems, such an idea could be a perfect fit for you or act as a complementary for your idea. Thus closed innovation leads to opportunity cost for many companies. On the other hand open innovation allows ideas to flow to find its perfect fit, or to find the complementary needs to make it transform into a product. Hence, open innovation is time and cost efficient compared to closed innovation.

### **2.3.1 Closed innovation**

In Henry Chesbrough journey to understand what leads a successful research center managed by a successful company fail to lead ideas to market. We did see that in Nokia touch screen technology that was invented by Nokia, still introduced to market by Apple that led to great loss for Nokia especially for a technology leader. Another example that Henry Chesbrough did focus on is Xerox's Palo Alto Research Center (PARC). PARC possessed all the resources, still they let many technologies either die or other players introduce to market first. PARC innovation in computer industry didn't have high returns as it should have for instance to XEROX. Chesbrough found that the main reason is in how XEROX or any other company with similar problem manages innovation. Chesbrough called it closed innovation paradigm where corporations and firms believed and set their strategy based on creating a competitive advantage through funding heavily research labs to discover new breakthroughs. Later they develop and implement them into products, manufacture them in their own factories and facilities, finally they sell it with high profit margin and fund research and R&D again with part of the profit. Such paradigm worked well not only for XEROX but for most of firms in 20<sup>th</sup> century. The more the firm vertically integrated in its capabilities from research, development and manufacturing, the more it can reach a high profit margin.

In Figure 2 the process of closed innovation is shown. Ideas represented by circles are filtered in the research phase, the selected one of them move to the development



and then to market. The ideas that get hold in the research phase usually either killed or patented to be or not to be used in future. Such paradigm leaves external resources and other markets untapped.

### CLOSED INNOVATION

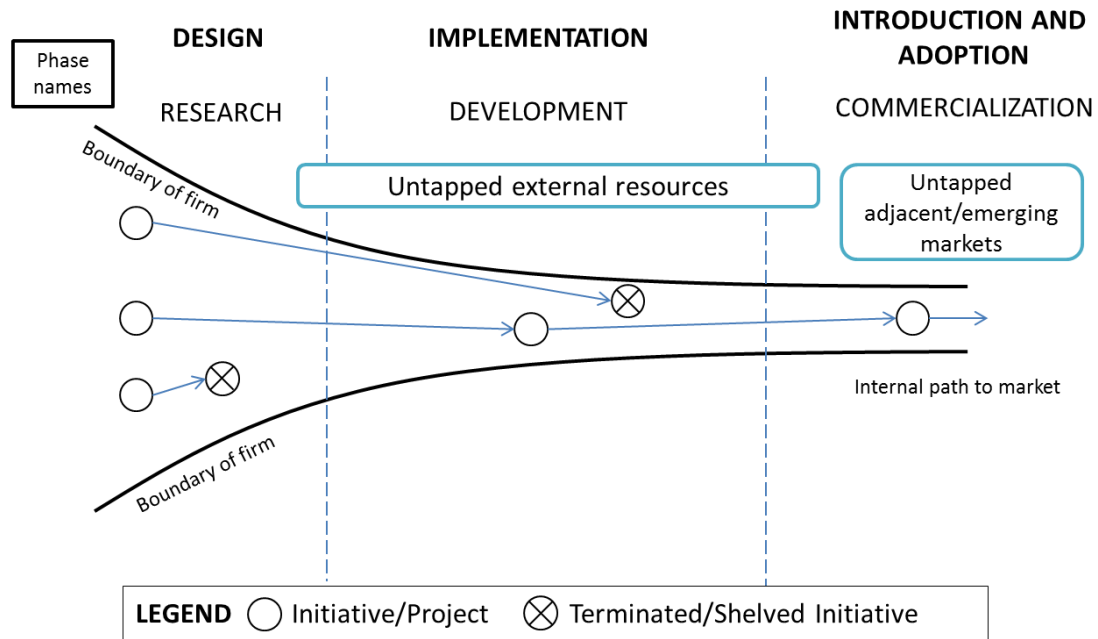


Figure 2: Closed innovation (adapted from Henry Chesbrough)

Chesbrough denoted three main factors that arose and undermined the closed innovation paradigm. Firstly, due to the increase in the mobility and availability of highly educated people, large amount of knowledge existed outside the firms R&D labs, this phenomenon of mobility led to the transfer of knowledge flow when an employee move from one firm to another. Secondly, venture capital has increased recently, which pushed innovators toward the possibility of developing their ideas outside of firm boundaries, thus the rise of entrepreneurial firms. Spin-offs and licensing agreements as well is considered an option for such rebellious ideas. Finally other firms, that can even be competitors, for instance suppliers in the supply chain, increasingly play an important role in the innovation process. Table 1 shows why it is not a must that successful ideas comes from the internal research of firms, in addition

to that, even if the successful idea is generated internally it is not a must that it gets developed internally.

Closed Innovation Principles	Open Innovation Principles
The smart people in the field work for us.	If we create the most and the best ideas in the industry, we will win.
To profit from R&D, we must discover it, develop it, and ship it ourselves.	External R&D can create significant value: internal R&D is needed to claim some portion of that value.
If we discover it ourselves, we will get it to the market first.	We don't have to originate the research to profit from it.
The company that gets an innovation to the market first will win.	Building a better business model is better than getting to the market first.
If we create the most and the best ideas in the industry, we will win.	If we make the best use of internal and external ideas, we will win.
If we create the most and the best ideas in the industry, we will win.	We should profit from others' use of our IP, and we should buy others' IP whenever it advances our business model.

**Table 1: Difference between closed and open innovation**

### 2.3.2 Open innovation

As a result of above, companies were forced to look into increasing the efficiency and effectiveness of their innovation processes. They started by looking outside the firm for ideas and disruptions in technology. Firms started to look into the possibility of cooperation with suppliers and even competitors with complementary goods or competing goods. Instead of losing the technology due to failing to use it, they started to license-out their unused innovations to other firms. ASML is one example, a spinoff

from Philips. Figure 3 shows the different approaches that firms adapted and existing methods to try to develop their innovation process.

### Existing innovation approach

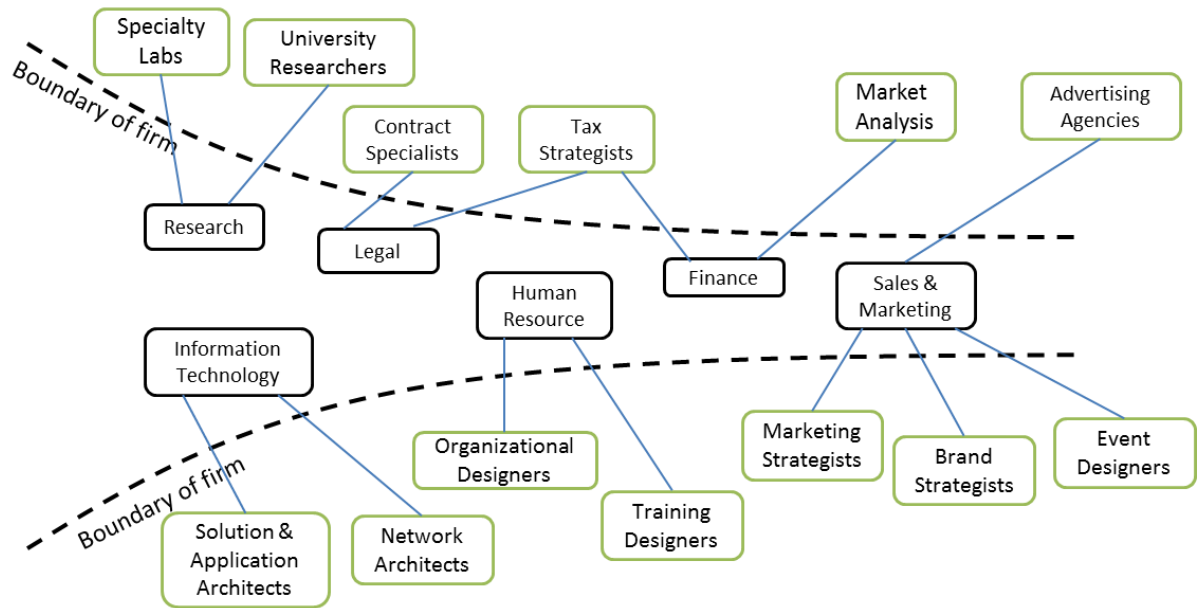


Figure 3: Existing innovation approaches utilized by firms

From the revelation of that need open innovation started to be identified as a concept, especially after Chesbrough terming the new paradigm of open innovation. Since open innovation backbone already existed in firms by their collaboration denoted in Figure 3. Applying open innovation is not risky. Most of the firms have at least a division who adapted open innovation. Identifying internal stakeholders who worked with external innovation partners and involving them in the development of open innovation programs is essential for firms to avoid the anxiety arise from introducing a new concept. Thus forming a multidisciplinary team in the firm is important to reach most of the firm divisions. A firm shouldn't go for open innovation to chase new ideas from new people or groups that is not internal; sometimes what the firm lack are not innovative ideas more than soliciting different types of ideas. The external resources will provide ideas that are born in a different context from

organizational structure, team compositions or the employees' profiles internally. Figure 4 shows the open innovation paradigm that should be adapted by firms and considered in their strategy.

### OPEN INNOVATION

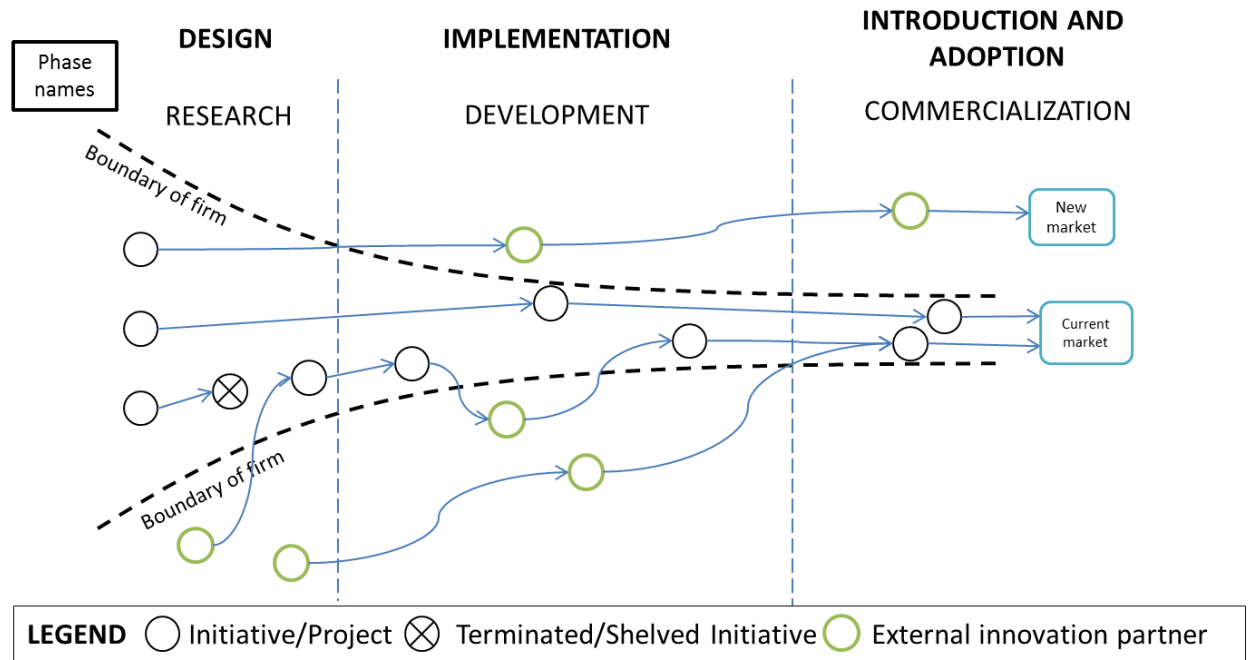


Figure 4: Open innovation model (adapted from Henry Chesbrough)

We can see that with the same number of ideas generated in design phase (3 ideas) more outputs and product to market were generated. The result is an outcome of external collaboration. An idea can be generated externally and captured by the firm. Any idea can be developed and implemented externally in case of lack of resources or knowledge. Finally an idea can be marketed through external resources as well. High-tech companies tend to prefer the right side of innovation funnel more than the left side, thus generate and develop the ideas internally and only commercialize them with collaboration with 3<sup>rd</sup> parties, an example of that in mobile industry is when mobile vendors hold an agreement with mobile operators and bundle their handsets with phone subscriptions to benefit from the market penetration of mobile operators. [9]

## 2.4 Open innovation and business modeling

From the definition of open innovation (OI), collaboration plays a major role in creating joint innovations between different constitutional stakeholders. Hence, networking as a concept is of great effect on innovation. Because of such importance, many researchers tackled the area of networking in innovative environments. In his approach to define networking in innovation, Nambisan [11] introduced network centrality as “network as the focal point and the associated opportunity to extend, optimize, and/or enhance the value of a stand-alone entity or activity”. That definition can be applied to reach a network-centric innovation. Thus, network centric innovation focus on external factors and how the network can accelerate innovation and create new innovations. Table 2 shows how Nambisan described the principle of network centric innovation.

Principles of network centric innovation	Description	Examples
<b>Shared Goals &amp; Objectives</b>	One or more goals that help bring the network members together and channel their diverse resources and activities.	Customer Community: Identify product flaws and contribute to product enhancement.
<b>Shared “World View”</b>	Common assumptions and mental models related to the innovation and its external environment.	Open source community: Shared understanding about the software product’s ties with other technologies and products.
<b>“Social” Knowledge creation</b>	Places the emphasis on interactions among the network members as the basis for value creation and on the cumulative nature of knowledge creation.	Inventor networks: Interactions among individual inventor, innomediary and large firms for development of new product concepts.
<b>Architecture</b>	Defines a set of systems,	Open source software

<b>of participation</b>	mechanisms and processes to facilitate participation in value creation and value appropriation.	community: Modular product architecture and GNU General Public License scheme.
-------------------------	-------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------

Table 2: Nambisan network centric innovation principle

From the previous definition of network centric innovation, Nambisan saw that the possession of leadership and the degree of innovation openness and space defines the different innovation paradigms and business models. Using the network leadership and the innovation space, Nambisan defined four types of innovative models: Orchestra, Mod-Station, Jam-central and creative Bazaar, as shown in Figure 5.

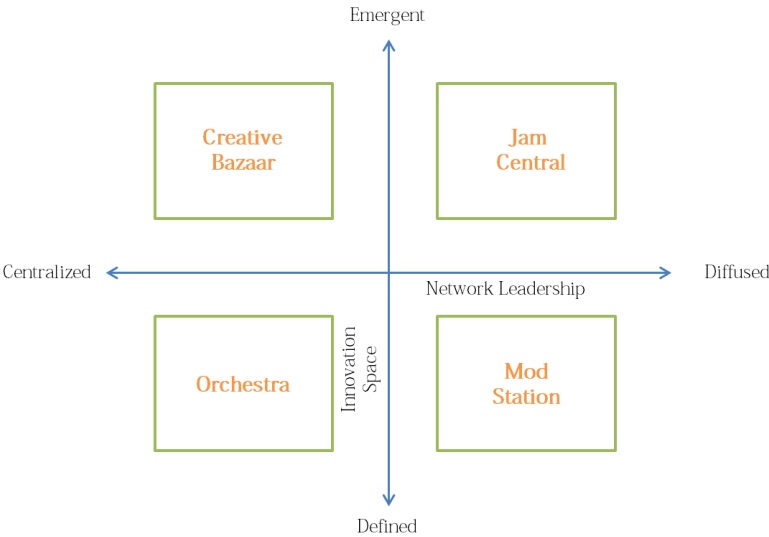


Figure 5: Nambisan innovation business models

The Innovation space resembles the degree of innovation definition. It forms two domains; Emergent domain is where the innovation paradigm is less defined and unstructured, in that domain the focus is on the unknown connections and knowledge networks, to explore novelties in innovation. While in defined domain, the innovation paradigm is clearly defined and structured, hence the emphasis is on the known connections and knowledge networks, leading to exploitation of innovations and improvement in efficiency of innovative process.

Similarly, network leadership is divided into two domains. Diffused domain is led by the whole network and community, including informal structure and linkages

between different players. Hence, that model adapts an etherarchical structure of communication, characterized by emergent and unplanned community-based behavior. On the other hand, centralized domain is formed of a dominant player that leads a more formal structure and linkages between players, hence adopting a hierarchical structure. [11]

These four domains reflected four business models that can be adopted as shown in Figure 5. Each adapts the characteristics of the two domains it lies in. The most appropriate open innovation business model in that context for ICT industry is the creative bazaar model; where the innovation is less defined, which gives more freedom and push the companies to search for new unknown connections and exploring other networks, at the same time having a dominant player and a formal structure that secure the company's management and strategic planning.

## 2.5 Towards open innovation standardization

Although from the above discussed research it might look like open innovation (OI) could reach a level of modeling, OI model cannot be generalized among different companies belonging to ICT; since each organization is inimitable having enclosed culture, operational dynamics and habitual actions. Thus the OI model needs to be modified based on the diverse configuration requirements by different organizational structures of the companies. [12]

In addition to that, firms use different open innovation policies. Such differences arise from difference in size, purposes and the degree of openness of innovation. There are four types of openness defined by [13]. A framework was developed based on the four types of openness and merging the inbound and outbound categorization. Such framework was developed to evaluation the different studies in the field of open innovation. Inbound (acquiring and sourcing) and outbound (selling and revealing) innovations versus pecuniary and non-pecuniary approaches where used to explain the reason behind the success and failure of some companies adopting open innovation by showing advantages and disadvantages of each type. Table 3 summarizes the outcome of such study showing the different types and the research done in each area.

	Outbound innovation Revealing	Outbound innovation Selling	Inbound innovation Sourcing	Inbound innovation Acquiring
<b>Logic of exchange</b>	Non-pecuniary—indirect benefits	Pecuniary—money involved in exchange	Non-pecuniary—indirect benefits	Pecuniary—money involved in exchange
<b>Focus</b>	Revealing internal resources to the external environment (e.g. Allen, 1983; Henkel, 2006; Nuvolari, 2004; von Hippel and von Krogh, 2003)	Out-licensing or selling products in the market place (e.g. Lichtenthaler and Ernst, 2009; Chesbrough and Rosenbloom, 2002)	Sourcing external ideas and knowledge from suppliers, customers, competitors, consultants, universities, public research organizations, etc. (e.g. Fey and Birkinshaw, 2005; Lakhani et al., 2006; Laursen and Salter, 2006a)	Acquiring inventions and input to the innovative process through informal and formal relationships (e.g. Chesbrough and Crowther, 2006; Christensen et al., 2005)
<b>Advantages and disadvantages</b>	shaping extent of openness Advantages driving openness Marshal resources and support (Henkel, 2006)	Commercialize products that are ‘on the shelf’	Access to a wide array of ideas and knowledge (Laursen and Salter, 2006a)	Gaining access to resources and knowledge of partners (Powell et al., 1996)



	Gaining legitimacy from external environment (Nuvolari, 2004)	Outside partners may be better equipped to commercialize inventions to the mutual interests of both organizations (Chesbrough and Rosenbloom, 2002)	Discovering radical new solutions to solving problems (Lakhani et al., 2006)	Leveraging complementarities with partners (Dyer and Singh, 1998)
	Foster incremental and cumulative innovation (Murray and O'Mahony, 2007; Scotchmer, 1991)			
<b>Disadvantages driving closeness</b>	Difficult to capture the benefits that accrue	Over-commitment to own product and technologies make it difficult to out-license (Lichtenthaler and Ernst, 2007)	Many sources create an attention problem (Laursen and Salter, 2006a)	Difficult to maintain a large number of ties with different partners (Ahuja, 2000)
	Internal resources can leak to competitors (Laursen and Salter, 2006b)		Difficult to choose and combine between too many alternatives (Sapienza et al., 2004)	Risk of outsourcing critical dimension of the firm's business

Table 3: Comparison of four different types of openness (Dahlander *et al.*)

## **Chapter 3: Methodology**

This chapter aims to describe the methods and models that will be used in analyzing the ICT ecosystem and the effect of open innovation. After finishing that chapter the reader will be familiar with the methods that will be used and why and how they will be used in coming chapters.

The analysis of open innovation in this study tackled three domains, hence, three main methodologies. Firstly, since innovation practices cannot be analyzed virtually without real-life analysis, interviews were conducted with top ICT companies. Secondly, to study the dynamics of open innovation, and for the main analysis modeling of innovation, system dynamics were used. Finally, value network analysis was used to show the static value network of different players active in the innovation ecosystem in ICT industry.

### **3.1 First Method: Interviews**

To select the most fitting interviews method first an overview of the existing methods needs to be explored. There are mainly three methods to use when conducting interviews: structured interviewing, semi-structured interviewing and unstructured interviewing [14]. In structured interviewing method questions to be asked are prepared in advance. No changes to the questions list can be applied during the interview, in another words, no question can be added or removed due to any change in the flow of the interview. Similarly, semi-structured interviewing method depends on a pre-defined set of questions. Still, the questions can be subjected to changes due to change in the interview flow, or as a respond to a certain answer for a question by the interviewee. In general, the questions act as a guideline to the interview. The third method of interviewing is the unstructured method. This method does not require pre-defined questions, in contrary; the interviewer can ask questions freely within the limited time of the interview. This method is usually considered the most informal one from all the three previously mentioned methods.

This study will adapt the semi-structured interview method, the questions can be found in Appendix A. The interviews were conducted in February, March and April of

2013. To cover diverse innovation approaches and understandings, different players had been interviewed from ICT companies (operators), universities, government, Incumbent R&D and vendor companies. The research protocol for the interviews is formed of three steps:

- 1) Review of scientific bibliography to analyze the main dimensions of open innovation.

- 2) Build semi-structured interviews questions. (Appendix)

- 3) Adapting multi-case nested experimental design. As defined by Yin, the multi-case nested experimental design is “an empirical inquiry that investigates a contemporary phenomenon within its real-life context, when the boundaries between phenomenon and context are not clearly evident, and in which multiple sources of evidence are used” [15]. The reason behind using this design for the interview is due to the behavior of open innovation as a phenomenon. Open innovation contains intangible constitutional parts that makes it hard to divide it into a list of questions for each part or section. In addition, open innovation is perceived in different way from one player to another, which implies multiple sources for information that is not a must to be synchronized together. Finally, innovation is related to real-life and the context. Hence, Yin method was adapted for the semi-structured interviews.

### **3.2 Second Method: System Dynamics**

System dynamics is a technique to observing and analyzing any complex system in a broad manner to understand its structure and interaction between its constitutional elements, and how changes in any area will affect the whole system and its constituent parts over time. Its usage extended to understanding the behavior of any complex systems over time [16].

The concept has its roots in engineering science, specifically in the development of feedback amplifiers for long-distance telephone lines at Bell Laboratories in the 1930s and the work of the MIT Servomechanisms Laboratory in the 1940s. The usage of system dynamics then expanded to multiple fields in technology, social science and management. The pioneer scientist in system dynamics is Jay Forrester, known as the founder of system dynamics. Forrester is a Germeshausen Professor Emeritus and

Senior Lecturer at MITSloan. He introduced system thinking that he excelled in engineering to social and human systems, which led to breakthroughs in many fields, such as value chain, sociology and many other systematic sciences [17].

The basic building blocks of any system dynamic model are stocks and flows, feedback loops and causal loops. Stocks are: Term for any entity that accumulates or depletes over time. While flows are: the rate of change in a stock. The feedback loop and causal loops are: studying the whole model to reveals the structure of a system [18]. Thus, analyzing system's behavior over a certain time period [19]. To understand the concept of system dynamics, figure 6 shows a simple chicken road crossing system dynamics model.

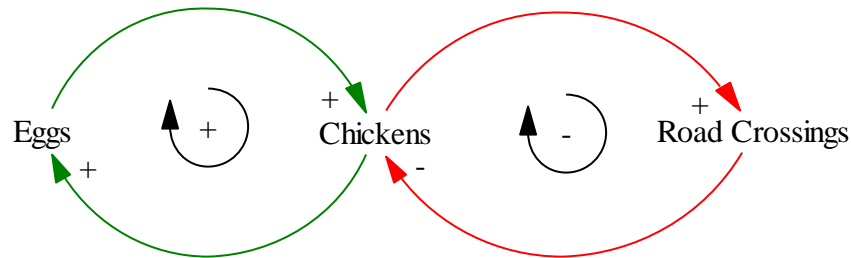
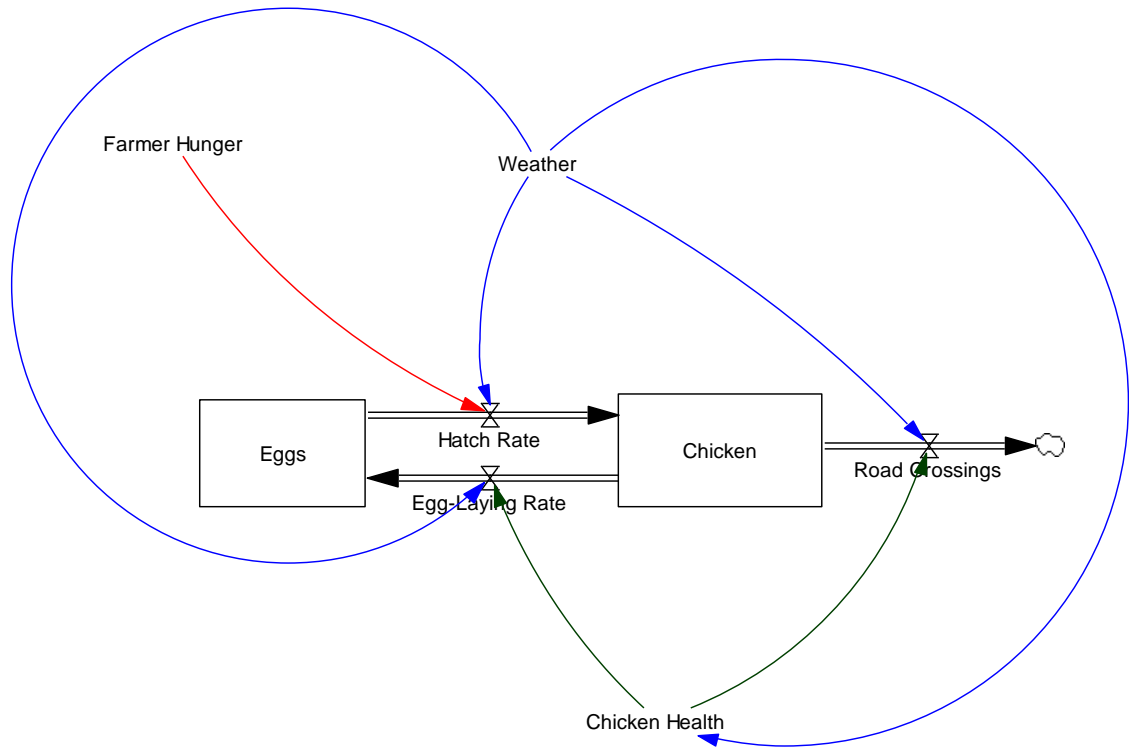


Figure 6: Chicken road-crossing system dynamics model

The model consist of eggs, chicken and road crossing as variables that can increase and decrease with time, and red and green line flows to express the interaction between different variables. Each flow can end with either positive or negative sign, which represents if the effect is positive or negative between the different ends of the flow connection. In our example, an increase in eggs increases the number of chicken. This resembles a positive causal loop. On the other hand, the increase in chicken will lead to more roads crossing, which diminish the number of chickens. Hence, it is a negative causal loops. For this dynamic system to survive, the number of chickens created from eggs needs to be greater than the rate at which they are killed off by getting to the other side of the road.

Figure 7 is a more detailed version of figure 6 system that explains the earlier finding. It considers eggs and chicken as two stocks that can increase and decrease based on external factors. This loop introduces new elements that affect eggs

becoming chickens process, including hatch rate and egg-laying rate. Still these rates are affected by farmer hunger, weather, and chicken health. A factor or element might affect more than one rate, for instance in our case, weather and chicken health affects the road crossing rate (as unhealthy chicken get killed by vehicles while crossing more often than healthy ones).



**Figure 7: Advanced Chicken road-crossing system dynamics model**

In the case of innovation system dynamics model is used to realize the flow of idea as one stock to reach a successful product as a final stock. This method will enable studying both static and dynamic behavior of innovation process by analyzing the different loops arising from the model. Thus, understanding how to control the innovation process and accelerate its functionality. The variables and elements in the model will be based on literature review, while the overall model will be inspired by Chesbrough model of open innovation [9]. The model will be represented later in the analysis section of the study.

### 3.3 Third Methods: Open innovation business aspects

#### 3.3.1 Areas of interest of open innovation

After building the system dynamics model, and elucidating the different affecting factors in open innovation, the existing ICT industry ecosystem will be explored, and different players with case studies will be described referring to the system dynamics model and using the areas of interest of open innovation model [20]. Areas of interest of open innovation will be used to position the different players in each case study in different locations in the paradigm of open innovation.

The reason behind the choice of this model is its synchronization with the system dynamics model that will be developed. Most of the current models describe open innovation more as an internal process that is dependent on external knowledge and actors, hence the internal perspective of innovation is still dominating. The foundation of open innovation model shown in figure 8 is a dynamic model that is formed of two dimensions: the locus of the innovation process and the extent of collaboration.

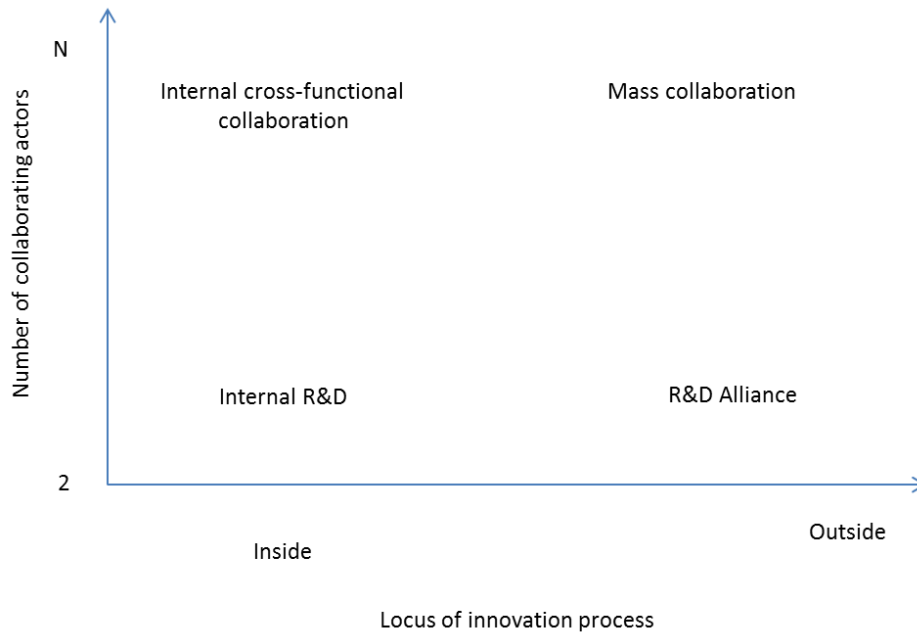


Figure 8: Areas of interest of open innovation model

##### 3.3.1.1 The locus of the innovation process

The locus of innovation resembles the boundaries within which the innovation process takes place. Open innovation in its definition includes external actors where

innovation originates, based on a collaborative environment. This is referred to as boundary spanning activity [21], where the boundary changes for the innovation. In such case, the innovation process cannot be only excluded to the R&D department of a firm. For instance, in the extreme opposite case, innovation can be bought by the firm from other third party firm. However in real-life situations, usually a mix between both happens. Hence, the locus of innovation as a dimension is major when it comes to the dynamics of innovation with external parties.

### ***3.3.1.2 The extent of collaboration***

Collaboration can take place between two parties in a B2B market or expand to even more than two parties, with large number of involved partners. The move towards open innovation leverages the benefit of collaborating with many parties, thus making use of the so called “wisdom of crowd” [22]. In general, the collective intelligence of a group of people or firms is able to generate more ideas and collect more knowledge. However, the challenge that exists in that domain is how to organize such collective intelligence and avoid chaos, in addition, how to aggregate the crowd of ideas and knowledge, and synthesize them. In that context, mass collaboration is one solution to benefit from such knowledge and crowd. A distinction must be done between mass collaboration and crowd sourcing. In crowd sourcing the focus is more on the firm and its targets, while the crowd is assigned tasks to support the innovation process. On contrary, in mass collaboration the focus is on the idea itself. It is self-organizing and bottom-up approach where users take different roles [23]. A real-life example of that is Wikipedia, the largest multilingual free-content encyclopedia on the Internet [24].

When the dimensions discussed above are connected, the model in figure 6 emerges giving different alternatives for open innovation. In the bottom left corner of figure 6, the traditional R&D model can be visible with low number of collaborating parties, this side of innovation is usually well developed in firms. The challenge exists on how to explore other areas. It is important to mention that open innovation requires frequent movement in the dimensions described in figure 6, hence the need of non-conventional management practices arise, the process of innovation becomes

more complex, and as an extreme, cognitive changes in the mindset of leadership in a firm might encounter changes [25]. This explains the complexity of implementing open innovation.

### 3.3.2 The long-tail business model

The term long-tail business model was coined by Chris Anderson [26]. In his best seller book “The long tail” Chris explained how selling less of large volume and high popularity products, and more of low volume and low popularity products could lead to a success in the business model. As shown in figure 9 the sum of sales of less popular products could be higher than that of high sales.

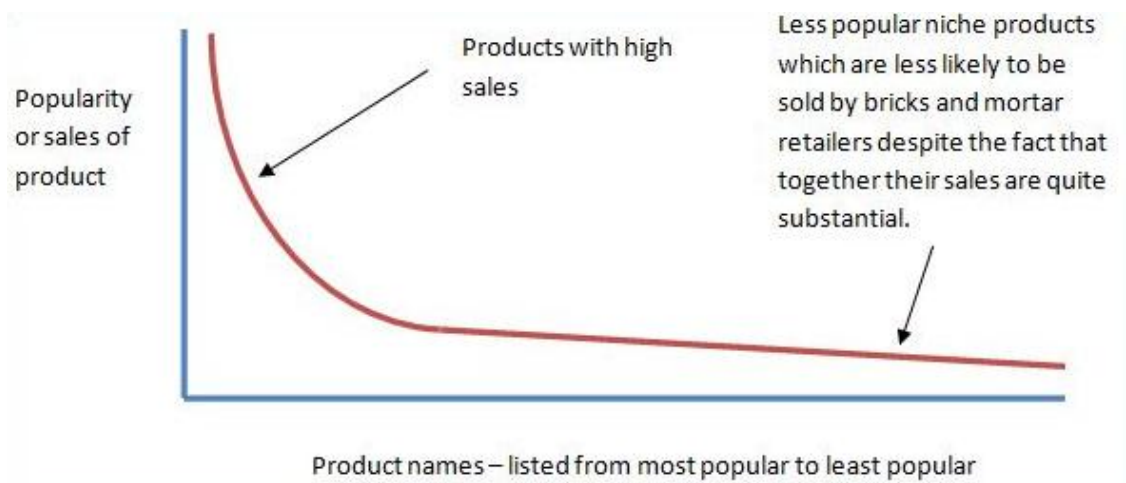


Figure 9: Long-tail business model

Firms tend to ignore the less popular products which led to the creation of opportunities in that side of market. “Myspace” is one example of that phenomenon. It focused on unpopular singers and musicians, and this was the core of their business model; reaching large breadth of niche segments [27]. The long tail model can describe social phenomenon as well. As described in [28], autopoiesis, which is the mechanism that makes living beings autonomous systems, utilizes long tail model in the context of social systems. For instance, It is shown how that although few biased decisions affects the majority of social system, still the sum of multiple remaining “tail” of small biased decisions have great effect, specially adding the factor of unconsciousness considering such decisions.



In the context of open innovation, long-tail model will be used to show how the long-tail model appears in knowledge creation process. In addition, it appears in the success of open innovation, specifically, open source solutions. This will be described later in the analysis section. In general, since innovation process is a collective process, the long-tail model has great impact on such process.

## Chapter 4: Interviews and case studies

Semi-structured interviews were conducted with company representative from different players in the ICT ecosystem. This chapter will describe the interviews and will aggregate the information gathered through these interviews. Later in the result section, the outcome of interviews will be described in more details.

Interviews were designed to study a complex case as adopting and applying open innovation in a dynamic and robust industry as ICT, hence Yin method was adopted [15] by designing semi-structured interviews and conducting them with different players from the industry. The selection of companies' representatives and the questions leading and controlling the semi-structured interviews were set to ensure validation of information following Yin method.

Total of five experts interviews were done. The questions of the semi-structured interviews were designed to validate the information from one player to another and to measure the different views for same topic by each interviewee. The interviewees were from major network providers, market leading mobile operators, government foundations and university professors working in innovation. As you can see in Table 4 the interviewees are selected ensuring having international experience and working in the same ecosystem. Finland is selected to analyze the innovation ecosystem as an innovation-driven country. Many reasons exist behind selecting Finland as a focus; Firstly Finland is always in the top 3 worldwide in innovation (2<sup>nd</sup> at the time this study was done). Secondly it is known as 1<sup>st</sup> on the world in terms of higher education and the availability of scientists and engineers [29]. Although the analysis is done in Finland, by analogy, the results can be applied in any innovative environment at any country.

Interviewee	About	Short Description
<b>Annakaisa Häyrynen (AH)</b>	AK is head of discovery project at Elisa Oyj. She has	Elisa Oyj is the leading ICT company in Finland. As head of

<b>Mobile Operator/ ICT</b>	more than 15 years of experience in innovation. She studied open innovation from the master Henry Chesbrough himself in Berkeley.	discovery project AK responsibility is to find new business opportunities, analyze them, validate them and foster them in the organization.
<b>Kalevi Ekman (KE) University/Research</b>	KE is professor at Aalto university. He is managing Aalto design factory. His research focus is in Integrated product development.	As manager of Aalto design factory, KE have long relation in collaboration between universities, research centers and companies. As described by KE "Design Factory is the symbiosis of the state-of-the-art conceptual thinking and cross-disciplinary hands-on doing. It leads a way towards a paradigm shift in education and business by providing a constantly developing collaboration environment for students, researchers and business practitioners" [30]. The design factory now opened in Chili, China, Australia. Expansion is ongoing and collaboration with universities around the globe is highly active.
<b>Janne Parantainen (JP) Mobile/ ICT Vendor</b>	JP is head of solutions, technology to business acceleration at Nokia Siemens Networks (NSN)	JP is responsible in NSN to produce proof of concepts and validation to ideas. To reach this result, his team collaborates with different parties till they reach validation and proof of concept for the idea, then the idea can move to further stages within NSN internal network.
<b>Kimmo Pentikäinen (KP)</b>	KP is member of the board of Tivit Ltd, a non-profit	Tivit is a "strategic center for science, technology and innovation

<b>Government Startup</b>	company in Finland that focuses on collaboration and funding research projects that are with industry. KP as well has long experience in entrepreneurship for last 10 years.	in the field of ICT in Finland launches research programs in the ICT industry and services sectors. It channels both private and public funding towards these programs”. As member of the board, KP analyzes the applications by universities and companies for funding. He provides his point of view and decision to the board based on the applications and his broad experience in the area of innovation and experience. The projects’ only gets accepted if it creates a cutting edge and breakthrough in technology in a market-driven approach [31].
<b>Raul Soderstrom (RS) ICT Vendor</b>	RS is innovation manager at Ericsson R&D head-quarters in Finland	Fostering innovation, RS work with his team to check possible business opportunities in different areas. Product design and fitting the innovation in Ericsson ecosystem is part of his team responsibilities. Collaboration with external resources is needed to achieve that.

Table 4: Interviewees

To analyze the whole picture, the whole innovation process players were interviewed and research was done in each field to ensure questions’ relevance. Since collaboration and communication is in the heart of innovation, accordingly some of the questions were repeated in some of the interviews. The reason behind that is to analyze the different opinions by introducing to each player the other player opinion about a topic or a problem in innovation process.

## **4.1 Interviews Results**

### **4.1.1 Perception of Open Innovation**

To identify and discuss the topic of open innovation it was important to check the understanding of open innovation by each player. For all of the players, collaboration is the focal point of innovation. Openness in open innovation comes from collaborating with different ecosystem and different collaborators category (JP). Another view is that openness lies in the openness of decision making, for instance most of the incumbent companies in the industry of ICT tend to create an engine for product development, and from that engine they create their own portfolios for existing time, next step and for far future (KE). In fact this decision by itself lead to the loss of openness; although they still didn't select what project they will run and they keep it open, they selected what products and ideas they will not adapt. Most of the dropped or delayed ideas turn to be a successful product at the end, an example of that XEROX and the invention of the computer mouse that Apple managed to introduce to market first and created a new market for computer mouse [32].

Another perspective of open innovation is its structure. AH defined open innovation process as a non-structured connection of people interested in same area, where ideas can come from any person, reach its maturity by an unstructured process. On the other hand other players see open innovation as a fixed process that varies inside. By analyzing that it was found that in the matter of having a fixed process, vendors and government organizations tend to prefer adopting a fixed innovation process while universities, research centers and ICT operators have a more non-structured process, important to note that all of them adopt a process and the fixation is at the level of project or idea not the whole ideas or projects.

To summarize, open innovation is an ecosystem, hence it includes multiple structures connected to each other in an evolutionary development.

### **4.1.2 What delays innovation?**

#### **4.1.2.1 *Absence of leadership***

Innovation process - being unstructured - needs someone to lead it, one of the main problems that ICT companies suffer from is the lack of such leader. As described by AH this leader or so called “Champion” has to be a good listener, able to have an analytical view of ideas to keep people interested in adopting the idea. And this explains the next issue.

#### **4.1.2.2 *Lack of interest***

Since innovation process is overall non-structured and evolutionary, it might be perceived by some of companies’ employees as fuzzy and unorganized, thus leading to loss of interest or passion towards ideas or projects, as a result a lowered performance.

#### **4.1.2.3 *Extreme Inbound open innovation***

In some cases firms prefer adopting only inbound innovation. As described by (JP) collaboration with customer is the optimum case. For (JP) the best innovation is that solve a customer issue and that is ignited by the need to find a solution for such problem. Although the innovation process is open in its last stages, in early stages such as scouting for ideas firms adopting such method tend to search only internally for ideas, filter them internally, then start the open innovation by searching for best collaborators. Problems or ideas can come from external resources but only in case of the awareness of an internal resource about it, usually by coincidence, such as meeting in a conference, customer follow up meetings, and so forth. If we will think about this issue in an ecosystem approach, firms tend to focus only into one “kingdom” in ecosystem, or even one “Phyla” in that “kingdom” which leads to extinction of ideas [33].

#### **4.1.2.4 *Mistrust***

In all kinds of innovation and collaboration trust must exist between different players. Mistrust leads to incomplete information transfer and knowledge share. For instance, (AH) described the problem that ICT vendors tends to try to get deeply

inside the operators internal business to find opportunities by gathering information about operators end-users, while operators prefer collaborating with another non-competing ICT operator where they can build – in their understanding – joint open innovation environment.

#### **4.1.3 What foster innovation?**

##### ***4.1.3.1 Entrepreneurship spirit***

Open innovation started in startup companies and SME companies due to the lack of resources and the need to collaborate with others to survive, since then open innovation developed as a process in all startups and a deep understanding aroused in that area [34]. Hence entrepreneurship and open innovation paired in term of existence. For large companies, applying open innovation would be easier by adapting entrepreneurial spirit inside the company, so called “Intrapreneurship” where organizations hire individuals who are responsible for turning an idea into a profitable finished product by innovation and risk management, these personals should have an entrepreneurship approach [35]. (AH) discussed this concept by relating the creation of startup-innovation environment to the creation of venture units inside organizations. These units collaborate with other units inside and outside the borders of the organization leading to innovative businesses.

##### ***4.1.3.2 Mixing the clusters***

When technology or technical experts are made to talk and interact with users this helps the innovation process. Once the isolated clusters from different organizations departments mix together and listen to customers and their needs, as (AH) named it “big crowd” of innovation, innovation is leveraged.

##### ***4.1.3.3 Monitoring the dwarfs***

Large organizations have to monitor what is happening in the parallel ecosystems, specially the entrepreneurial ecosystem. Since innovation is adopted in a faster pace in small companies, more ideas and proof of concepts are generated. Large organizations can keep track of that since it might lead to collaboration with another small company, or acquisition of such company technology. “Apple” - as a successful

company in terms of innovation - accommodates this method, for instance when “Apple” noticed the high competition from “Google” and “Nokia” in location services, “Apple” decided to make a counter response on that leadership. “Apple” acquired “WiFiSLAM” (leading indoor positioning company) once they monitored their success and decided to absorb their technology and introduce its ecosystem to their larger “Apple” ecosystem [36]. A successful innovative organization is not only that can create ideas, but can absorb external ideas and ecosystems into its own ecosystem.

#### ***4.1.3.4 Active government and universities activities***

Every innovative ecosystem requires a catalyst to foster innovation and encourage it. One of the most successful cases is government owned organizations that fund research projects joint with industry. Taking Finland as a case, government created “Tekes” - the Finnish funding agency for technology and innovation - [37]. Still as (AH) denoted as well even if such government funded organizations didn’t exists, the ecosystem will figure out another mechanism. This analogy is logical especially when we think about open innovation as a whole ecosystem that has its own evolving network. For instance, large organizations can for a cluster that plays the same role of government funded organizations.

Universities are an educational and innovative environment by its structural bases. This makes it an important player in fostering innovation. As (KE) said “curiosity is from university”, universities are research based, which means that they try to reach findings and ideas based on given facts. Organizations and universities shouldn’t only have collaborations, but co-creating process. Organizations can introduce the practical inputs for research. Universities can create innovation factories where university co-creates with companies, Aalto design factory is one example of that. (KE) mentioned that although Aalto design factory [30] is very useful to innovation, the utopia of innovation would be that there is no need for such innovation factory as innovative environment will be familiarized in the whole university.



## **Chapter 5: Analysis**

Based on the previously discussed background, and the conducted interviews, this chapter will analyze the ICT innovation ecosystem and will represent a system dynamics model for innovation.

### **5.1 Dynamics in open innovation**

#### **5.1.1 Innovation dynamics**

In that section system dynamics will be used to explain how open innovation starts and diffuses in innovative environments, including ICT industry. System dynamics employs two main principles for modeling: feedback processes, and stock and flows, when it comes to modeling innovation system dynamicists have not followed any hierarchical principle in modeling innovation processes. This section will start by introducing an industry-level analysis of innovation. Later a system dynamics model for open innovation will be discussed taking Chesbrough as a reference to open innovation process [9], in that context the study will utilize the absorption capacity of ideas and technologies in firms.

Industry-level modeling is one approach in trying to analyze innovation. In that approach, innovation is perceived as a resource likewise other resources in the firms system, where competition in ICT industry arises in the availability of such resources. Thus the focus is in a macro level without exploring details of innovation processes in firms; focusing on industry dynamic behavior. An industry in that case acts as a feedback system formed of firms and market including the products and services of firms [38]. Figure 10 shows the system dynamics model for the feedback system described. The system consists of two main feedback loops: firm evolution and market evolution.

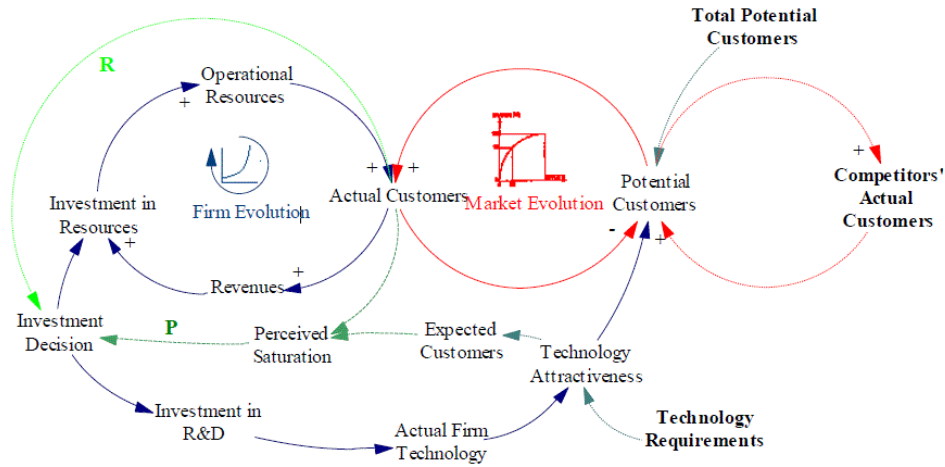


Figure 10: Industry-level system dynamics model

Firm evolution loop is a reinforcing (positive) feedback process. Following the diagram, the firms invest at the entrance of industry in operational resources, such investment leads to attracting more customers, hence more revenue. The revenue is then used for more investment leading to more customers forming a positive loop. The decision to invest in operational resources is controlled by two main elements, the actual number of customers' growth, and the perceived level of saturation: relationship between expected customers and the actual number of customers.

Similar concept can be studied in the Market evolution feedback loop. The increase of actual customers for firms in competition decreases the number of potential customers, since population is limited. The loop in the right side of Figure 10 is representing the potential customers and competitors actual customers' effect. The competition remains till there is no potential customer, in other words, a decline occurs in sales till it stabilizes at replacement level [39]. In the model above potential customers is function of the technological attractiveness from innovation. Technology attractiveness is function of firm's existing technologies with respect to the technology requirements of such potential customers. Hence a firm innovation should target improving firm's technology to fit with the customers' needs.

The green arrows in the diagram represent the different strategy types in firms, reactive (R) and proactive (P) [38]. The reactive from its name depend on past information and the feedback from the loop, while the proactive depends on

expectations regarding market size with a feedback from market to update or validate such expectations.

The above approach emphasizes the firms' decision making and investment in relation to market evolution. It shows as well that when market reaches a level of saturation, competition arises. Such analogy acts in a macro level of innovation; moreover, it implies closed innovation approach of internal investments and R&D more than open innovation.

### 5.1.2 Open innovation system dynamics model

This section includes the approach adopted in this study to model open innovation as a system dynamics model. Referring to Chesbrough description of open innovation [9] an idea pass through three main phases before it is considered as a successful product. These three phases are research, development and commercialization. System dynamics will be used to model such stages of ideas and check the different factors affecting such processes. Figure 11 shows the basic structure of the dynamics in open innovation. The system is formed of four main rates and four main stocks. The rates are describing the transition of an idea from one stage to another, while the stocks describe the stored ideas/product count in that phase.

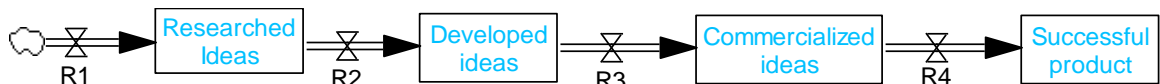


Figure 11: System dynamics model Of Open Innovation

#### 5.1.2.1 R1: Rate of introducing new ideas into the firm

The first rate in the process of innovation is that of firms gathering and collecting ideas internally and externally. This rate is very important as the whole innovation process will be delayed in case of any disruption in that rate. The raw idea in its context is open and affected by many variables; hence, the rate of introducing new ideas into the firm is affected by many variables, both internally and externally as shown in Figure 12.

There are four main variables having effect on rate R1: external knowledge network partners, knowledge outdate rate, knowledge absorption and new internal

knowledge creation. “*External knowledge network partners*” refers to the partnerships done by the firm with other firms, to reach this target firms need to expand their knowledge network, thus, “*establish external knowledge networks*”. On the other hand, establishing external knowledge network requires high level of trust from other firms. In addition, the firm *level of trust* is directly affected by the successful products, resembling market power, and the range of partnership the firm achieved with other firms [40]. *Knowledge compatibility* is a major factor as well in establishing external knowledge networks; firms tend to seek cooperation with other firms and organizations holding higher level of knowledge in certain focus areas. However, such difference should be limited or it might lead to lack of understanding and communication between the two entities [41].

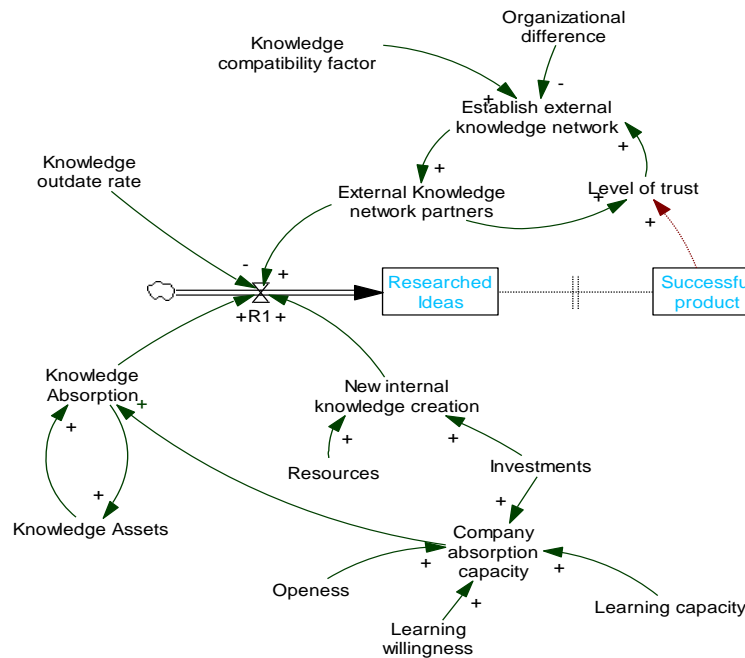


Figure 12: Introducing new knowledge system dynamics model

The second key variable is knowledge outdate rate, it is the natural process of knowledge become obsolete, thus become invalidate, unserviceable or even wrong in some situations. In that case an established knowledge and absorbed knowledge will be of no value to a firm.

The third variable is Knowledge absorption. Firms’ absorption capacity is a major factor in the innovation process, it is defined as firm recognition of external value,

assimilate it and make use of it in the innovation process till commercialization phase [42]. Hence, absorption capacity will be active in each stage in innovation process, furthermore affects the rate of transition from one stage to another. Internal knowledge has an indirect effect on a company

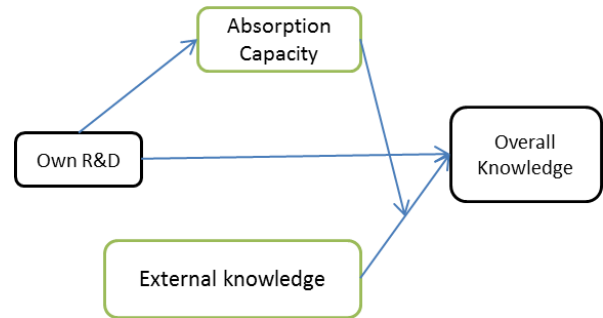


Figure 13: Absorption Capacity

absorption capacity. The firm own knowledge increase its capability of adapting new knowledge, therefore, an increase in external knowledge the firm can acquire, leading to an increase in the overall technical knowledge. In [42] the external “new” knowledge was represented in the form of spillovers of competitors or extra-industry knowledge, adapting the same model with the introduction of open innovation and free information exchange between cooperating firms, figure 13 shows the basic concept of absorption capacity.

From that context, and in the stage of open innovative environment and gathering ideas, *knowledge absorption* is one of the major factors affecting directly the rate of adapting new knowledge. The firm knowledge assets, as explained in absorption capacity, will have a direct relation with the knowledge absorption of the firm. Adding to that, the *company absorption capacity* will lead to an increase in the knowledge absorption capability of a firm. In addition, the knowledge capacity of a firm increases by the increase in the investment, for instance, R&D investments [43]. The openness of the firm, referring to the firm attitude towards accepting new knowledge, have a direct impact on the firm absorption capacity, the more the firm is open, the more it will be able to realize more knowledge [44]. The quality of the firm employees reflects on its ability of absorbing new knowledge. The employees *learning willingness* and *learning capacity* have a direct positive impact on the overall firm ability to absorb external knowledge [45].

*New internal knowledge creation* is the final active factor or variable in the case of introducing new ideas to the firm. Although the focus in open innovation is on collaboration and external knowledge absorption, the importance of internal knowledge shouldn't be excluded. Firms need to maintain sufficient *investments* and

allocate needed *resources* to achieve the targeted internal new knowledge created, this factor importance increase with the internationalization of a firm [46].

#### **5.1.2.2 R2: Rate of developing ideas**

The second rate in the process of innovation is the rate of developing ideas. It is the rate of transforming an idea to a concept developed. Three main factors affect that rate: External development network, ideas implementation capacity and technology outdate rate, figure 14 shows the dynamics of the system. The *external development network* is of similar behavior as the external knowledge network partners discussed in R1. The more there are external partners working in cooperative environment with a firm, the more it is possible to find the matching profile between the partner and needed technical skills to develop the idea. Furthermore, to increase the number of partners, a firm needs to establish and extend their technology development network. In contrary, although Internal and external agile development have a positive impact on the innovation process, the structural holes, including both internal and external, could have a positive or negative influences on the innovation. Hence, the optimal structure of such collaboration depends on the objectives and is different from one case to another [47]. Consequently, *technological capability difference* arises as a factor affecting directly the external network. It can be realized as a tuning variable for the effectiveness of the network. Level of trust plays an important role similarly to its effect in R1 [40], which shows the connection between the different rates, which will be discussed later. That is, although extending the network inherits a positive effect, in the case of development, it could be more complex.

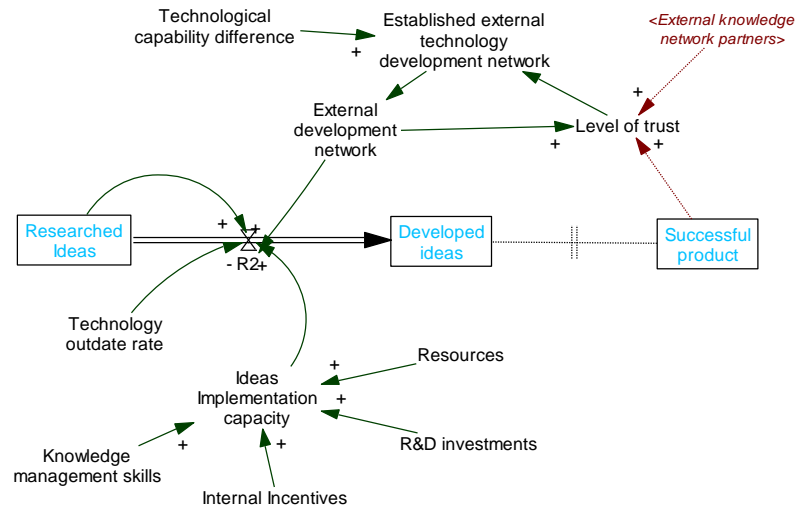


Figure 14: Developing ideas system dynamics model

The second main factor is *Idea implementation capacity* (IIC). The factor is a reflection of the company absorption capacity discussed in R1 and shown in figure 9. It is defined as the realized absorptive capacity of a firm utilizing the external knowledge and digesting it within internal technologies. Thus, idea implementation capacity is a continuation of the process of knowledge absorption. From its definition, IIC positively affects the rate of developing an idea. In addition, many factors affect IIC. Resources and R&D investments have a direct impact on the size and growth rate of ICC. In contrary, firms tend to limit resource allocation and R&D investments, especially at development phase, when collaborating with other firms as a defensive method to their royalties [48]. In addition, the lack of proper *internal incentives* in a firm, and the lack of regularizing *knowledge management skills* have a direct correlated influence on the firm ICC. Hence, any firm has to break their ego-defense mechanism building proper incentive policies and providing appropriate knowledge support [49].

The final major factor affecting the rate of developing an idea is *technology outdate rate*. Technology outdate is defined as the rate at which a technology becomes obsolete relevant to the technology existence. In another words, the longer the technology exist, the more probable it will lose attractiveness and vanish, with the possibility of introducing a replacement technology in the market.

### 5.1.2.3 R3: Rate of commercializing and marketing the idea

The rate of commercializing and marketing an idea is the rate at which the developed ideas (products) move to commercialization and business units of a firm, hence studying the business case and potential customers for that developed idea and associated product/s. Three main factors affect that rate: *resources acquired*, *business models generated* and *technology market relevance*. Figure 15 shows the system dynamic model of that rate. Resources acquired factor represents the number of resources that is allocated for fostering the developed ideas to business units. This allocation could be through external resources allocation or internal resources allocation. As defined in “resource-based theory” concept presented by Robert M. Grant, strategy of firms in allocating resources and acquiring them is of high importance and can be a major competitive advantage, still had been neglected compared to the focus on external threats and risk in competitiveness [50].

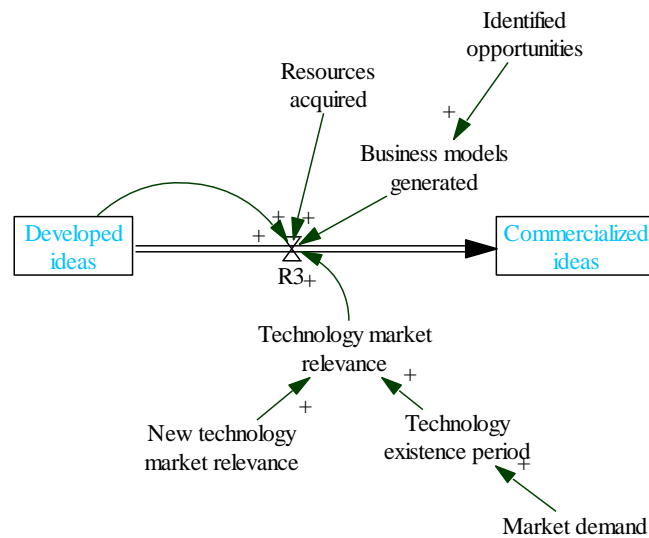


Figure 15: Commercializing ideas system dynamics model

The second main factor, business models generated represents the number of business models that can surround a developed idea. This factor emphasizes the importance of linking developed ideas and R&D with the business ecosystem. The focus here is not in linking the business model with firm strategy, but in linking the innovative idea with a new business model or an existing one. In contrast, a flexible and editable business model is required by an innovative firm. With the increase in



R&D costs and decrease in product life cycle, such open business models enable firms to decrease the R&D cost by leveraging external investments, in addition, avoid restricting its model in the market it serves, thus having insight and *identify opportunities*, which have a direct effect on the business model generated [51].

The final direct affecting factor is the *technology market relevance*. Although an innovative developed idea is a valuable asset for a firm, the relevance of that innovation to the market is a crucial factor. This is relevant in both cases of creating a new technology or using an existing one in a different business model or as a different deliverable. In contrary to new technology, an existing technology has an expiry, resembled by *technology existence period*. The *market demand* present on the technology controls its lifetime and usefulness, the market could be eager to adapt the new updates and technologies, or it could be looking for a different totally new technology, thus an update to an existing technology or reapplying it could be of no benefit. This concept of market demand-pull is visited in many researches in innovation and invention focusing on technological advancements and innovations and its relation with the market demand [52]. Still this research focused on demand as the dominant factor in innovation and perceived it as a single factor, ignoring the market demand dynamics, hence this research shows the initial evaluation but does not give the whole picture of innovation-demand relation [53] [54]. The same reasoning is adapted in this thesis, where innovation process is considered a dynamic process, and this leads to the final phase coming next of having a successful product from the commercialized idea. This section will explore more different factors affecting the demand process and commercialization of products.

#### **5.1.2.4 Rate of reaching a successful product or change in a product**

As introduced in the previous section, the final part of the system dynamics of open innovation process is concerning reaching a successful product out of the innovation. The success of such process is linked to the diffusion of innovation within the innovative environment. The purchase of a new service or device in ICT industry is more complex than a simple additional device or service purchased by a customer. Due to the technological and innovative context, the customers usually take into

consideration the different features included in the product [55]. Research in that topic can take two approaches, the first approach considering the diffusion of innovation, taking into account customer decision making. The second approach is related to behavioral economics and types of customers, which, stand-alone, a broad topic to discuss. The research here will start by introducing the relevant topics related to types of customers, and deduce from it the useful information related to diffusion of innovation.

#### **5.1.2.4.1 Types of Customers**

Research in categorizing customers focused on the state of a customer during the diffusion process and based on the attitudes difference between people. For instance, Roger divides them into five categories: Innovators, early adopters, early majority, late majority and laggards [56]. While Malcolm focuses more on the role of a person in the process where the knowledge or information regarding the product exists, he divides them into three main categories: Maven, Connector and Salesman [57]. In contrary, in innovation process the transfer of knowledge relevant to the innovation and its diffusion is the focus, hence, different types of personalities, with different combinations of characters. In addition, the dynamic state of customers led to the change in the customer “type” during the diffusion process [28]. For instance, a customer or user could be an already existing user of a similar product or same earlier version of same product; hence, the customer can act as an early adopter and persuade others towards the technology, since he has previous experience. At the same time, the innovation could function as a replacement to an existing technology provided by same firm or a competing firm; in that case, the customer could be a laggard or could be considered exactly as a new customer. Thus, to keep the focus on the topic, the research delivered here will analyze the dynamics of innovation taking into consideration the situation that represents all types of customer activity and diffusion process, without getting into specific details of each type of user or customer.

#### **5.1.2.4.2 The system dynamics model**

The model will include two rates representing the looping in innovation process and dynamics in customer status. This model is an adaptation of Bass diffusion model. Bass diffusion model has been used to describe the diffusion of innovations in system dynamics [58]. As shown in figure 16, two rates will be introduced: R4 as the adoption rate and R5 as the replacement rate [58].

#### *5.1.2.4.2.1 R4: Adoption rate*

It is the rate of adapting a commercialized idea by users, thus leading to successful product.

The adoption rate of a new product is function of the purchase rate by which a customer buy a product, the effect of advertisements on a product or considering an innovation, represented by adoption rate from advertisements. The adoption from word of mouth where other customers adapted the innovation starts to promote the concept, finally the repeated purchase rate of the product by previous experienced customers who decided to adapt an update of a previous innovation or product.

#### *5.1.2.4.2.2 R5: Discard rate*

It is the rate of abandoning a product by a user and observing a replacement.

The rate is affected mainly by the product outdate rate. This rate is determined from the existing period of a product in a market combined with the market demand on a new technology, thus new product or product feature [59].

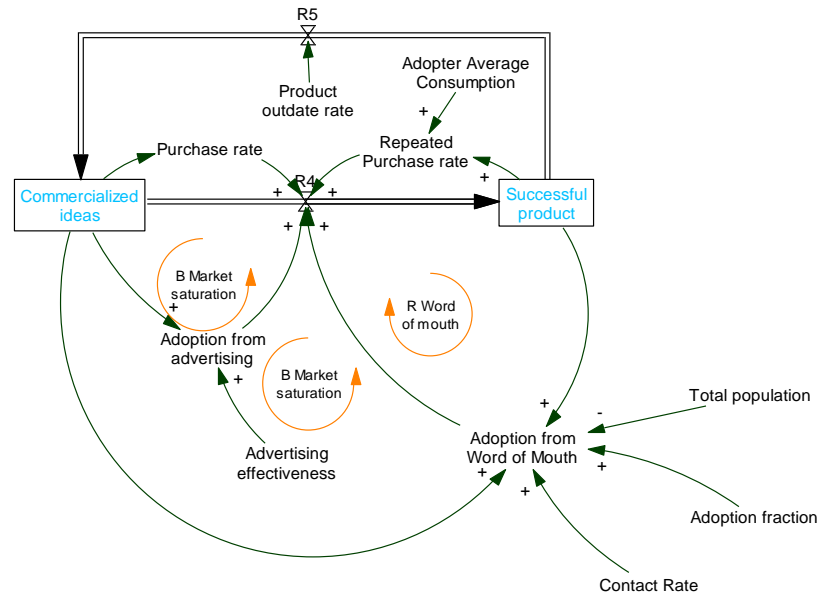


Figure 16: Product success system dynamics model

In general in the default Bass diffusion model omitting R5, when an innovation or the resultant product is introduced to market, the adoption rate R4 depends only on the customers or people adopted the idea from advertisements or external resource of information. With time, and with the decrease in the potential customers stock, the word of mouth between people starts to dominate the rate of adoption [58]. The number of contacts represented in the contact rate for each adopter, and the probability of success of such contact has direct effect on the adoption from word of mouth. Since adopters are a division of total population, with time, market saturation takes control and the growth rate decreases, till no more potential adopters exists. Still as introduced in the model above, part of the adopting customers will be reverted and reconsidered as potential customers of new innovations, or will positively affect the rate of adoption directly, in that case, the previous purchase acts as an advertisement [60]. Hence, with the introduction of R5 the behavior of Bass model changes, thus leading to a different result.

### 5.1.3 Causal Loops

This section will analyze the different causal loop diagrams, constituted from the causal relationship between different elements in the model. A causal loop diagram is

used to study the feedback effects of a system. It will summarize the logic in the models and stress on important points in the overall open innovation system dynamics model.

The first causal loop occurs in the early stage of innovation, where knowledge absorption and researching is pursued. As show in figure 17 an increase in the absorption of knowledge in a firm leads to an increase in the firm assets of ideas, thus affecting its innovation process. In addition, the increase in the assets leads to an increase in the overall knowledge and understanding of the firm, thus enabling it to absorb knowledge more fluently and creatively. This emphasizes the importance of absorption capacity to firms, and the need to focus on fostering it by manipulating the affecting factors discussed in the rate of introducing ideas section (R1).

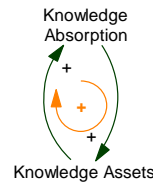


Figure 17: Knowledge creational loop

The second causal loop is the knowledge network loop (figure 18). It emphasize how that having a strong research resources in a firm will lead to more possibilities of reaching a successful product, which in fact increase the level of trust towards the firm in its ecosystem, and results in expanding its knowledge network. Eventually, the rate of introducing new ideas to the firm will increase.

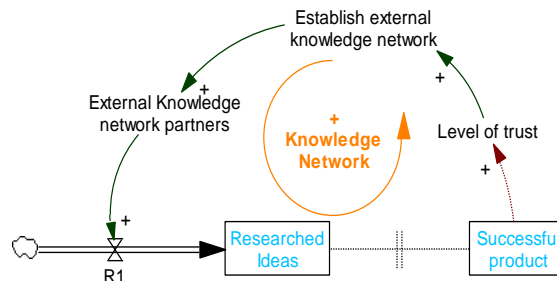
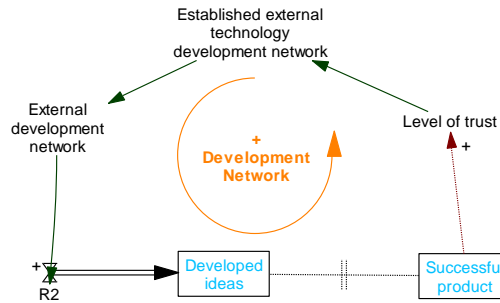


Figure 18: Knowledge network loop

The third causal loop is the development network loop. As shown in figure 19, the development of one idea leads to the increase in trust level of a firm, hence, enabling

expanding their external technology development network and partners. Which feeds the rate of developing ideas (R2), causing a more possibility to develop new ideas making use of established partnership and the development network built in the firm ecosystem.



**Figure 19: Development network loop**

As you might noticed, the knowledge network and development network loops have a similar behavior. The reason these two loops were emphasized separately is to show how one element as “level of trust” affects the whole innovation process in multiple areas. One outcome from this two loops is the importance on raising the level of trust of a firm. This activity has a “chicken and egg” phenomenon, since trust is built by having a successful product portfolio of products and collaborations, while to reach a high level of product portfolio and expand collaboration network, a high level of trust is needed. This explains the need of heavy investment in the innovation process at the beginning to improve internal knowledge creation and development skills, thus leading to the creation of a successful portfolio and a decent trust level to start with. Hence, firms should invest in the innovation process, specially at the early stages.

Besides the previously mentioned loops, as in any BASS model system dynamics, two main loops exist and can be found in figure 16. Firstly, a balancing market saturation loop, this loop represents the result of a limited number of customers, thus resulting in market saturation with the decrease of opportunity in targeting customers. Secondly, a reinforcement loop that represents the positive effect of word of mouth. As the adoption from word of mouth increases, the adopters increase, hence, the adoption from word of mouth increases again.

In addition to the common two loops, in our model, two more loops exist: initialization loop and loyalty loop. The market initialization loop shown in figure 20

represents the return of adopting customers to potential customers stock. Although this loop is considered a threat to a firm, at the same time it is an opportunity to target these customers again as potential customers, including those of competitors. This loop has an indirect effect on the market saturation loop as well, due to its influence on potential adopters.

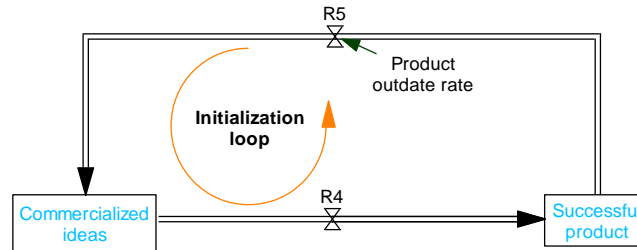


Figure 20 Market Initialization loop

The loyalty loop shown in figure 21 represents the customer loyalty to a product or innovation. As defined in [61], customer loyalty is “the strength of the relationship between an individual's relative attitude and repeat patronage”. It represents the repurchases of an updated version of a product or innovation directly without the need of targeting the customer. This loop is an important loop that affects positively the rate of adoption of an innovation. Hence, firms need to focus on building the loyalty of customers by launching and conducting loyalty programs and campaigns.

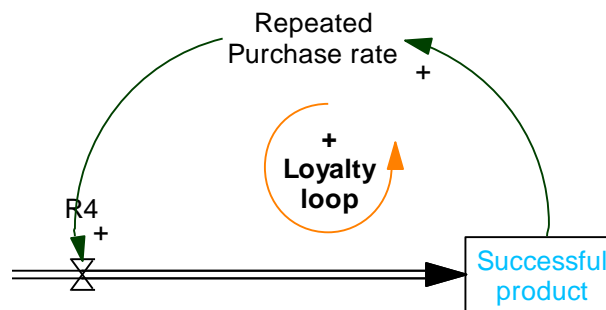


Figure 21 Customer Loyalty loop

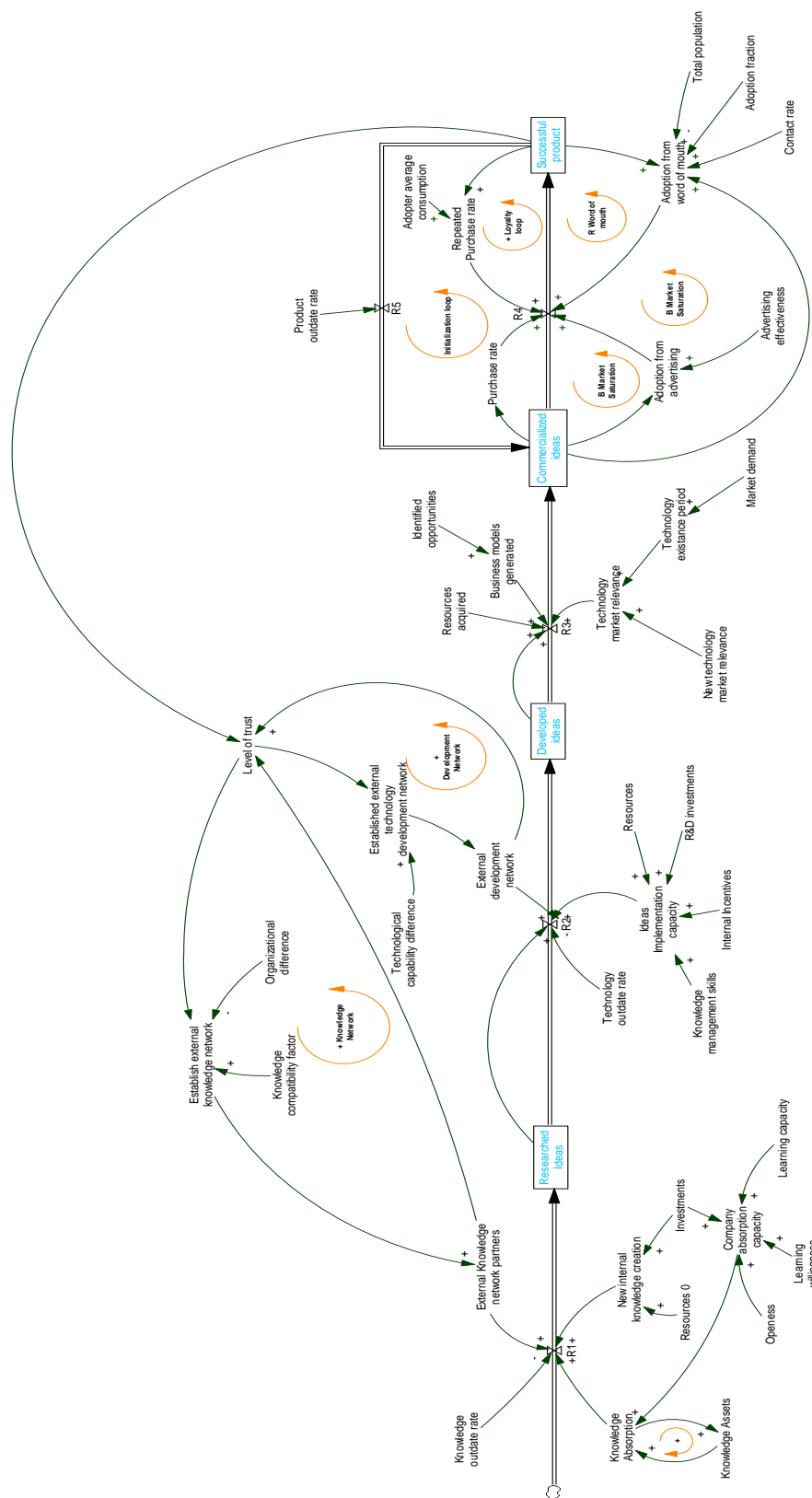


Figure 22 Detailed Open innovation system dynamics model



## 5.2 Open innovation in business

This section will analyze the different business approaches and phenomena in ICT industry related to adapting open innovation. The section will start by analyzing where each of the current big players exists, and what approach they prefer. Later, there will be a focus on open source as one example of open innovation. The section will end by introducing the future expectations in the ICT industry relevant to innovation process.

### 5.2.1 Business approach in innovation

The current players in mobile industry adapt different approaches in innovation. As shown in figure 23 and using the areas of interest of open innovation model [20], the differentiating factor is the number of collaborating actors reflecting the extent of the firm network, and the locus of innovation process, wither the firm is externally centered or internally centered. For instance, in mobile vendors section, Nokia Siemens Networks (NSN) tends to have an internal locus of innovation with minimal number of collaborations. This was concluded from the interview done their where their tendency is to general ideas internally based on customer needs, and then create a collaborating network only around such idea. Their current focus and technology vision is more towards the mobile broadband to keep the lead in that area, without exploring other paradigms which might cause distraction [62], thus limiting innovation possibilities. This behavior could be a strategic move to keep the firm stable, especially in the current changes in the industry. On the other hand, Ericsson tends to have more open approach. With their focus on broad areas, such as Communication, Data & Knowledge, Internet of Things, Media Coding, Security and Smart Cities, let the collaboration with almost any entity possible [63]. For example and from the interview, currently they have collaboration with Aalto University where they submit a raw idea and students are open to develop such idea and prototype it freely with no pressure on having a final product. Hence, leverage the innovative skills of students. Project work is called Product Development Project (PDP) [64]. In the mobile platforms section in the industry, Google Android, Apple iOS and Microsoft/Nokia compete together, still each of them have a different approach.

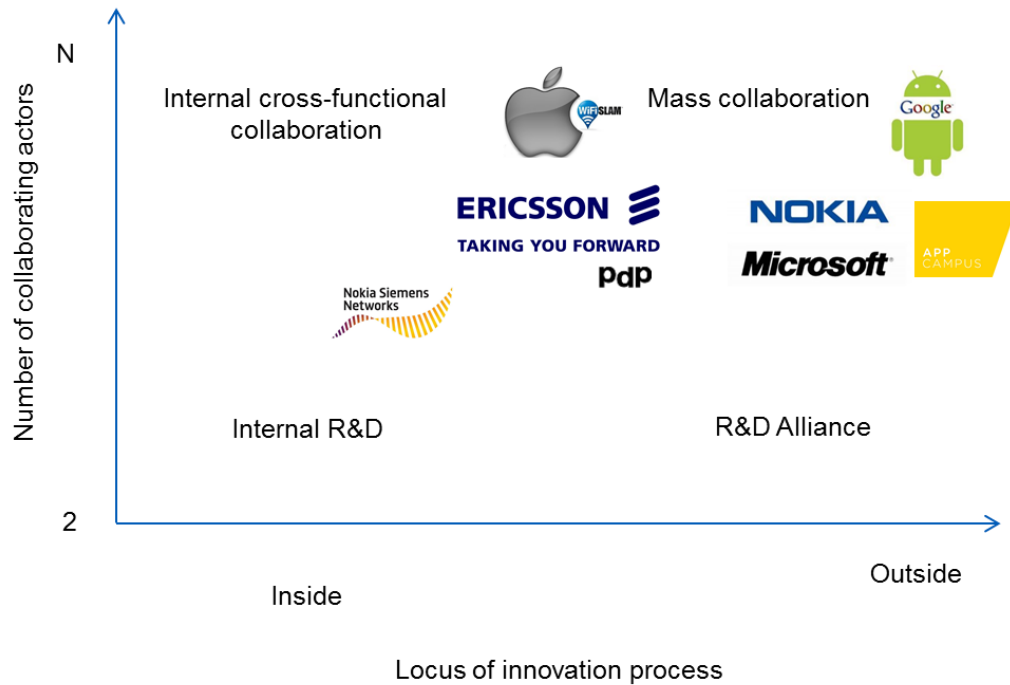


Figure 23: Current ICT players' areas of interest of open innovation

Google with their open source platform Android adapt the most open strategy in innovation. There is no limited number of collaborators, with total focus on the outside of the firm. They reached such situation by leveraging the crowd. It is important to notice the difference between crowd sourcing adapted by some firms, and the mass collaboration that Google encourage. Crowd sourcing focus is forming a network around an idea, while the mass collaboration is forming a network that as an outcome, an idea will be generated. Android is open to any developer from developing their own application, till the extent of developing their own version of Android OS. On the other hand, Apple prefers to keep a middle position by absorbing external ideas and developing internal ones. Hence, for Apple absorption capacity and monitoring the dwarfs of SME companies are major target to succeed. For instance, when Apple noticed the move of its competitors, Google and Nokia in indoor positioning services, they acquired the leading SME company in that area, WIFISLAM, thus adding their knowledge to their internal development and innovation system [36]. Finally, Nokia with its collaboration with Microsoft kept Microsoft windows phone as a closed platform; still they encouraged developers to develop applications over that platform, which enabled them to benefit from external (outside) ideas. A clear example of that is

founding the open innovation center in Finland by Nokia Research Center (NRC) [65], and launching the App Campus project by Microsoft, Nokia and Aalto University with funds reached 18 Million Euros, to attract external talents [66].

### 5.2.2 The long-tail phenomenon

The process of open innovation includes the long-tail effect in its foundation. On the creativity level, most of the breakthrough innovations are found in the “long-tail” side of the distribution curve of innovation [67]. In a research conducted by Novozymes, the world leader in bioinnovation [68], they analyzed the data gathered from their innovation and idea posting platform after launching an innovation campaign. They found out that the idea posting distribution within active members and idea posters had a long-tail distribution shown in figure 24.

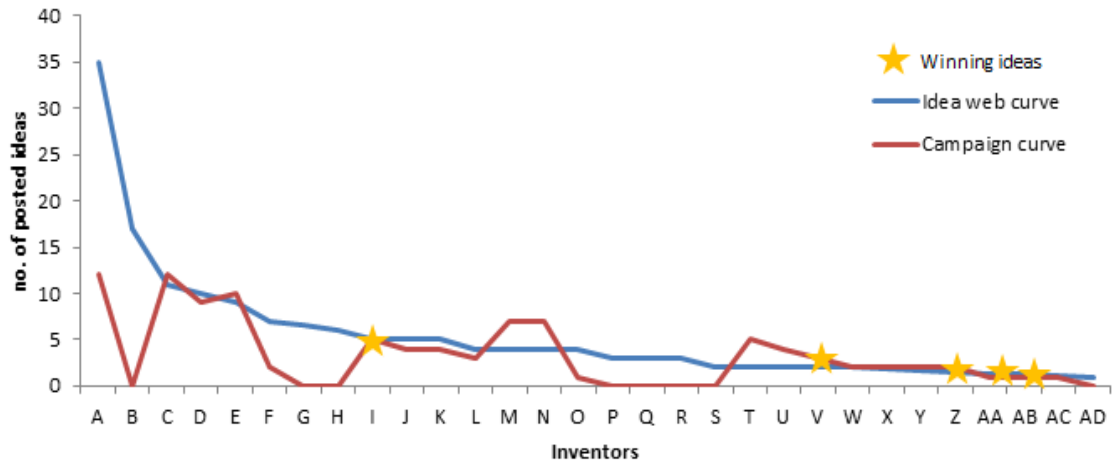


Figure 24: Idea posting distribution long-tail curve (adapted from Novozymes)

With further analysis, they found out that a high activity group of only 8 inventors (A-H) accounted for 70% of the ideas on their portal, while the remaining that post infrequently or occasionally on the portal (I-AE) accounted for 30%. The results of the campaign showed that the winning ideas are all from the tail of ideas posted. This emphasizes the importance of the long-tail in creativity and in idea gathering.

The same concept reflects on the ICT industry. Firms should keep an eye on the long-tail of gathered ideas, especially that innovation is essentially a process of recombinant search, where multiple ideas can be combined together to form a stand-alone idea that can be implemented. For instance, different features can be thought of

for a smart phone, still the combination of these ideas that then had been developed into features is what makes the differentiation factor for the new smart phone.

With the introduction of Android phones, and based on Gartner and IDC statistics, in figure 25, it is clear how Google succeeded to dominate the smartphones market by applying an open source model of innovation, where developers can freely develop applications and publish them in Android “Play Store”.

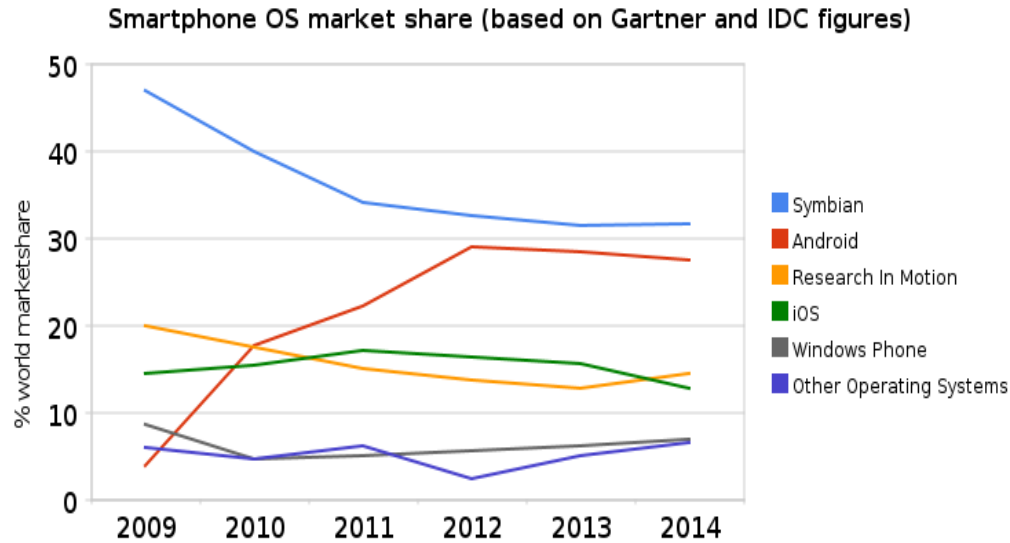


Figure 25: Global smartphone market share – based on Gartner and IDC

The long-tail effect on the business aspect of open innovation is proven as well in the domain of open source, the long-tail model can be observed in revenues from apps in applications stores, such as Android “Play Store” of Google. The top 25% Apps in store ranking account only for 28% of total revenue from the 7€ Billion market of mobile applications (Figure 26) [69], Thus the true value exists in the long-tail, the 75% in our case. It is remarkable to notice the difference in the long-tail between Android and Apple iOS, where the first tend to have a more decaying exponential tail compared to the second, this reflects the higher openness in Android compared to iOS. This was explained previously in the business approach section, where the interest in open innovation of Google and Apple were plotted together (figure 23).

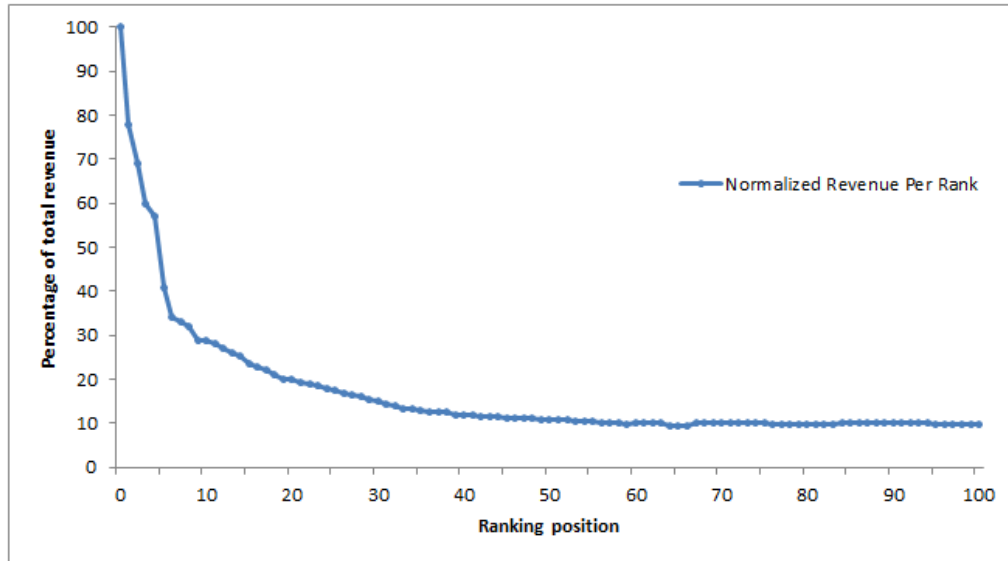


Figure 26: Revenue per App Rank (Adapted from Ferry Analytics)

With the app economy expansion, combined with a marketplace that reduces the power of brand recognition, such as Android “Play Store”, accumulated market revenue continues to shift to the long tail. In another words, the ecosystem of app development and smart phone applications changed that middle-class app developers dominates the market. In this economy, the deep pocket investments are not the differentiating power more than the innovativeness of an idea.

### 5.3 Future in ICT

The future in ICT tends to support innovativeness and openness. It is expected that the firms that hold an open innovation system, such as Ericsson in mobile vendor section and Google in mobile OS, will lead. Still, having an open platform enables high risk and competition. For instance, emerging entrants can compete in the market share much easier, especially if they managed to adapt a more open and organized system of innovation and if they focused on certain market niche. This was clear in the Android accelerated market share dominance. On the other hand, there is ongoing development in other strong competitors to develop an open platform that might take the lead from Android in future. Firefox announced the launch of their smartphone OS with a target of 10% of the global smartphone market in first year. Firefox will focus at

the lower-cost segment [70], for instance, they are planning launching \$50 devices to emerging markets, such as India and China [71]. Another upcoming competitor is Tizen, the linux based OS developed jointly by Intel and Samsung. It is focusing on developing a consistent user experience across devices, Tizen will include SDKs and APIs that should enables developers to develop applications over the open source platform in multiple programming languages and over multiple device segments [72].

The innovation process is accelerated in the hardware side as well with the growing SME companies. After the latest acquisition by Apple to WIFISLAM, Senseg, a growing startup that was coined by times magazine in their top 50 invention list, might be a new target by incumbent firms after their invention in touchscreen technology that enables users to feel the screen, with a sensitivity of feeling different textiles [73]. The competition is not only in the software side or hardware standalone, the new emerging Finnish company Jolla explores the mobile industry with an open source smartphone in both hardware and software side in a revolutionary approach in the industry, there main target is the emerging market, especially in far east, such as China. [74]. Hence, the future in ICT will be to the firms that are able to accelerate their innovation process, wither it is an incumbent firm in its industry, or a growing one. It is evolutionary expected that the future will be in exploring the emerging market, where high demand exists while few supply able to satisfy the needs of that market [75].

## **Chapter 6: Conclusion**

Innovation is a strategic demand for firms in the current competition vigorous ICT industry. To achieve a competitive advantage, firms need to accelerate their innovation process. This need requires creating a clear innovation model and strategy that can be divided into elementary factors, to be separately analyzed further. This study emphasizes the importance of adapting an open innovation model by firms, enabling them to accelerate the innovation process. To address this topic, the study proposed approaching open innovation as a dynamic process. To analyze open innovation, Literature review was undertaken in various topics related to innovation. In addition, interviews were conducted to grasp an overall understanding of the current innovation ecosystem, and define the various elements in innovation process. Consequently, a model was proposed in the analysis section representing open innovation as a dynamic process.

### **6.1 Key Findings**

The first finding is that several factors exists in firms that leads to delaying innovation, such as the absence of leadership, lack of interest, extreme Inbound open innovation and mistrust. On the other hand, firms can accelerate their existing innovation model and foster it by several factors, such as entrepreneurship spirit, mixing the clusters between technology and business, monitoring the dwarfs of SME companies and working in an environment includes active government and universities activities.

The second finding is that Open innovation is an ecosystem that includes multiple structures connected to each other in an evolutionary development. This emphasizes the time factor effect on innovation. Likewise, as an outcome from the system dynamics model of open innovation introduced in the study, it is clear that the challenge in innovation process is not only in each affecting factor standalone, but in the interaction and mutual effect of different factors on each other. Thus, it is important for firms, while planning their strategy in innovation, to take into

consideration such behavior of the innovation system and cognize a whole picture of the innovation process.

Finally, the study emphasized the important causal loops found out of the system dynamics model presented in the analysis section. For instance, it is important to focus on firm's absorption capacity, which is the ability of a firm to absorb knowledge generated [42]. In addition, the customer loyalty is important to keep active by launching different loyalty programs. Furthermore, the study showed the effect of innovation on the market saturation.

Business wise, the study discussed the different strategies that firms adapt relevant to innovation, and the emerging business phenomena out of innovation strategies, such as long-tail. Consequently, the firms with more open innovation process are growing faster than other firms. The study ends with a forecast of the ICT industry future based on the different innovation approaches that current players adapt.

## **6.2 Future Research**

A continuation on this study can be performed by updating the system dynamics model and running simulations based on quantitative data gathered. Hence, research can be conducted on data mining and stochastic analysis over the different factors affecting innovation. More focused research can be conducted as well to analyze the long-tail phenomenon in open innovation, where the value of an idea comes from the cumulative long-tail. Finally, future research can explore more the micro-level of open innovation by investigating the human-centric side of innovation process. This will need introducing cognitive and behavioral theories, thus updating the system dynamics model variables with neuroscientific and sociological knowledge.



## References

- [1] C Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail.*: Harvard Business School Press, 1997.
- [2] PF Drucker, "The coming of the new organization," *Harvard Business Review*, vol. 66, no. 1, pp. 45-53, 1988.
- [3] TM Hout, ME Porter, and E Rudden, "How global companies win out," *Harvard Business Review*, vol. 60, no. 5, pp. 98-108, 1982.
- [4] H. A. Simon, "Technology and Environment," in *Management Science* 12., 1973, pp. 1110-21.
- [5] M. A. Schilling and C. E. Vasco, "Product and Process Technological Change and the Adoption of Modular Organizational Forms," in *Winning strategies in a deconstructing world.*: eds. R. Bresser, M. Hitt, R. Nixon, and D. Heuskel, 2000, pp. 22-50.
- [6] Joachim Henkel, "Champions of revealing—the role of open source developers in commercial firms," *Industrial and Corporate Change*, vol. 18, no. 3, pp. 435-471, December 2008.
- [7] Ulrich Lichtenthaler and Holger Ernst, "Opening up the innovation process: the role of technology aggressiveness," *R&D Management*, vol. 39, no. 1, pp. 39-54, July 2008.
- [8] Adrienne Kardon Crowther Henry Chesbrough, "Beyond high tech: early adopters of open innovation in other industries," *R&D Management*, vol. 36, no. 3, pp. 229–236, June 2006.
- [9] H. Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting from Technology.*: Harvard Business School Press, 2003.
- [10] G A Stevens, "3,000 raw ideas= 1 commercial success," *Research technology management [0895-6308]*, vol. 40, no. 3, 1997.
- [11] Satish Nambisan and Mohanbir Sawhney, *The Global Brain.*: Wharton School Publishing, 2008.
- [12] F. Malerba, "Innovation and the evolution of industries," *Journal of the Evolutionary Economics*, vol. 16, pp. 3-23, 2006.
- [13] L. and Gann, D.M. Dahlander, "How open innovation?," *Research Policy*, vol. 39, no. 6, pp. 699-709, 2010.
- [14] Colin Robson, "Real World Research: A Resource for Social Scientists and Practitioner," in

- Real World Research: A Resource for Social Scientists and Practitioner.*, 2002, p. 270.
- [15] R. K. Yin, "Case Study Research: Design and Methods," *Sage, Newbury Park, CA.*, 1989.
- [16] Jay W. Forrester, "System dynamics, systems thinking, and soft OR," *System Dynamics Review*, vol. 10, no. 2-3, pp. 245-256, Autumn (Fall) 1994.
- [17] Jay W. Forrester, "The Beginning of System Dynamics," *Banquet Talk at the international meeting of the System Dynamics Society Stuttgart, Germany*, July 1989.
- [18] John D. Sterman, *Business Dynamics: Systems Thinking and Modeling for a Complex World*. New York: McGraw, 2000.
- [19] DH Meadows, *Thinking in Systems: A Primer*, D Wright, Ed.: Earthscan, 2008.
- [20] M., Fredberg,T. and Ollila,S. Elmquist, "Exploring the field of open innovation," *European Journal of Innovation Management*, vol. 12, no. 3, 2009.
- [21] MG Jacobides and S Billinger, "Designing the boundaries of the firm: From “make, buy, or ally” to the dynamic benefits of vertical architecture," *Organization Science*, vol. 17, no. 2, pp. 249-261, 2006.
- [22] J Surowiecki, *The Wisdom of Crowds: Why the Many Are Smarter Than the Few and How Collective Wisdom Shapes Business*. New York, United States Of America: Anchor, 2005.
- [23] D. Tapscott and A.D. Williams, *Wikinomics: How Mass Collaboration Changes Everything*. New York, United States Of America: Penguin Group, 2006.
- [24] Wikipedia. (2013, May) About Wikipedia. [Online]. <http://en.wikipedia.org/wiki/Wikipedia:About>
- [25] J. Buijs, "Innovation leaders should be controlled schizophrenics," *Creativity and Innovation Management*, vol. 16, no. 2, pp. 203-210, June 2007.
- [26] C Anderson, *Long tail, the, revised and updated edition: Why the future of business is selling less of more.*: Hyperion Books, 2008.
- [27] myspace. myspace. [Online]. <https://new.myspace.com/>
- [28] Kalevi Kilkki, "Customer Satisfaction," in *An Introduction to Communications Ecosystems*. Helsinki, Finland: Amazon Distribution, 2012, pp. 216-217.
- [29] The world economic forum, "The Global Competitiveness Index ," 2012–2013.

- [30] Kalevi "Eetu" Ekman. (2008) Aalto Design Factory. [Online]. <http://www.aaltodesignfactory.fi/about/>
- [31] Tivit Oy official webpage. About Tivit and its activities. [Online]. <http://www.tivit.fi/Company>
- [32] Jeremy Reimer, "A History of the GUI," *arstechnica*, pp. 1-28, May 2005.
- [33] D. L. DeAngelis and L. J. Gross, *Individual-based models and approaches in ecology: populations, communities and ecosystems.*, 1992, pp. xix-525.
- [34] David Mayle, "Managing innovation and change," in *Managing innovation and change*. London, England: Sage Publications, 2006, pp. 127-128.
- [35] Robert D. Hisrich, "Entrepreneurship/Intrapreneurship," *American Psychologist*, vol. 45, pp. 209-222, February 1990.
- [36] Tony Costa, "Apple + Wi-FiSLAM = Game on for Indoor Location," *Forbes Tech*, March 2013.
- [37] the Finnish funding agency for technology and innovation Tekes. About. [Online]. <http://www.tekes.fi/en/community/Home/351/Home/473/>
- [38] Martin Kunc, "Revisiting Porter's Generic Strategies using System Dynamics," in *Computational Analysis of Firms' Organization and Strategic Behaviour*. UK, 2010, ch. 6.
- [39] F Bass, "A new product growth for model consumer durables," *Management science*, vol. 15, no. 5, pp. 215-227, 1969.
- [40] Jane E. Salk, Marjorie A. Lyles Peter J. Lane, "Absorptive capacity, learning, and performance in international joint ventures," *Strategic Management*, vol. 22, no. 12, pp. 1139-1161, December 2001.
- [41] X. and Y. Liu Wang, "System dynamics Model of Tacit Knowledge Transferring," *Science of science and management of Science and Technology*, vol. 5, pp. 90-94, 2006.
- [42] Wesley M. Cohen and Daniel A. Levinthal, "Absorptive Capacity: A New Perspective on Learning and Innovation," *Administrative Science Quarterly, Special Issue: Technology, Organizations, and Innovation*, vol. 35, no. 1, pp. 128-152, March 1990.
- [43] Wenpin Tsai, "Knowledge Transfer in Intraorganizational Networks: Effects of Network Position and," *The Academy of Management*, vol. 44, no. 5, pp. 996-1004, October 2001.
- [44] Ammon Salter Keld Laursen, "Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms," *Strategic Management*, vol. 27,

- no. 2, pp. 131-150, February 2006.
- [45] Robert F. Hurley and G. Tomas M. Hult, "Innovation, Market Orientation, and Organizational Learning: An Integration and Empirical Examination," *Journal of Marketing*, vol. 62, no. 3, pp. 42-54, July 1998.
- [46] Jan Johanson and Jan-Erik Vahlne, "The Internationalization Process of the Firm-A Model of Knowledge Development and Increasing Foreign Market Commitments," *International Business Studies*, vol. 8, no. 1, pp. 23-32, 1977.
- [47] Gautam Ahuja, "Collaboration Networks, Structural Holes, and Innovation: A Longitudinal Study," *Administrative Science Quarterly*, vol. 45, no. 3, pp. 425-455, September 2000.
- [48] Scott Gallagher Joel West, "Challenges of open innovation: the paradox of firm investment in open-source software," *R&D Management*, vol. 36, no. 3, pp. 319-331, June 2006.
- [49] Gabriel Szulanski, "Exploring Internal Stickiness: Impediments to the Transfer of Best Practice Within," *Strategic Management Journal*, vol. 17, no. Special Issue: Knowledge and the Firm, pp. 27-43, Winter 1996.
- [50] Robert M. Grant, "The resource based theory of competitive advantage: Implications for strategy formulation," *The resource based theory of competitive advantage*, pp. 114-135, 2001.
- [51] Henry W. Chesbrough, "Why Companies Should Have Open Business Models," *MIT Sloan management review*, vol. 48, no. 2, pp. 22-28, 2007.
- [52] J. Schmookler, "Invention and economic growth," *Cambridge*, p. 332, 1966.
- [53] David Mowery and Nathan Rosenberg, "The influence of market demand upon innovation: a critical review of some recent empirical studies," *Research Policy, Stanford University, Stanford, CA 94305, USA*, vol. 8, no. 2, pp. 102-153, April 1979.
- [54] Alfred Kleinknecht and Bart Verspagen, "Demand and innovation: Schmookler re-examined," *Research Policy*, vol. 19, no. 4, pp. 387-394, August 1990.
- [55] Kalevi Kilkki, "Customer Satisfaction," in *An Introduction to Communications Ecosystems*. Helsinki, Finland: Amazon Distribution, 2012, ch. C, pp. 212-213.
- [56] E. M. Rogers, "Diffusion of innovations," in *Diffusion of innovations*. New York, United States of America: Free Press, 2003, p. 281.
- [57] M. Gladwell, "The Tipping Point," in *The Tipping Point*. New York, United States of America:

- Back Bay Books, 2000, p. 34.
- [58] John D. Sterman, "Business Dynamics: Systems Thinking and Modeling for a Complex World," in *Business Dynamics: Systems Thinking and Modeling for a Complex World*.: Irwin Mc Graw-Hill, 2000, ch. 9, pp. 332-344.
- [59] Giada Di Stefanova, Alfonso Gambardella, and Gianmario Verona, "Technology push and demand pull perspectives in innovation studies: Current findings and future research directions," *Research Policy*, vol. 41, no. 8, pp. 1283–1295, October 2012.
- [60] Frank M. Bass, "Comments on "A New Product Growth for Model Consumer Durables", The Bass Model," *MANAGEMENT SCIENCE*, vol. 50, no. 12, pp. 1833–1840, December 2004.
- [61] Alan S. Dick and Kunal Basu, "Customer Loyalty: Toward an Integrated Conceptual Framework," *Journal of the Academy of Marketing*, vol. 22, no. 2, pp. 99-113, Spring 1994.
- [62] Nokia Siemens Networks NSN. (2013) Nokia Siemens Networks Technology vision. [Online]. <http://www.nokiasiemensnetworks.com/innovative-thinking/technology-vision>
- [63] Ericsson. (2013) Ericsson Research Focus. [Online]. <https://labs.ericsson.com/research-topics>
- [64] Aalto. (2013) PDP - Product Development Project. [Online]. <http://pdp.fi/>
- [65] NRC Open Innovation Center. (2013) Nokia research center innovation center about page. [Online]. <http://research.nokia.com/page/12409>
- [66] Microsoft. (2013) Microsoft App Campus. [Online]. <http://www.appcampus.fi/>
- [67] Lee Fleming, "Breakthroughs and the "Long Tail" of Innovation," *MITSloan Management Review*, vol. 49, no. 1, pp. 69-74, Fall 2007.
- [68] About Novozymes. Novozymes leading innovation company in biotechnology. [Online]. <http://www.novozymes.com/en/about-us/Pages/default.aspx>
- [69] Flurry Analytics. (2011) Study on smartphone applications' stores. [Online]. <http://blog.flurry.com/?BBPage=2>
- [70] Lorrain Luk. (2013) The Wall Street Journal. [Online]. <http://online.wsj.com/article/SB10001424127887323469804578522970435729366.html>
- [71] Sasha Goldstein. (2013) Daily News. [Online]. <http://www.nydailynews.com/news/world/mozilla-offer-50-smartphones-running-firefox-os-article-1.1361945>

- [72] Tizen. Introducing Tizen, the new smartphone operating system. [Online].  
<https://www.tizen.org/about>
- [73] Senseg. (2013) Senseg, the emerging touch screen technology. [Online]. <http://senseg.com/>
- [74] Jolla. (2013) Jolla. [Online]. <http://jolla.com/>
- [75] Ernst&Young, "Valuation drivers in Telecommunications industry," ey, 2013.

## Appendix

This section includes the interviews questions used in the Yin semi-structured interview method used to conduct interviews for this study.

Interviewee: X

Company: X

Position: X

Thanks for your time, this interview is a semi structured interview conducted for writing a master thesis on adapting open innovation in telecom ecosystem. If it is ok to you the interview will be recorded. All the information in the interview will be only used for the research.

- Can you please describe the tasks or work you used to do or still do related to innovative work. For instance collaboration with other players?
- What does open innovation means to you?
- Which open innovation approach is adopted by the companies belonging to the ICTs industry?
- What are the existing IPR issues when it comes to innovation?
- Who should be the leader of innovation?
- Which types of collaborations are carried out by the companies and which are the dynamics that characterize it?

- How do you see different players in telecom industry have different interest in open innovation?
- Do you still see a gap between player X and player Y? Is there is a missing link?
- How innovative environment including employee's behavior and company's organization changed in the last few years? Do you recall a certain decision or action done by you or by one of the companies you worked for that accelerated innovation?
- What do you see as best practice to accelerate technology to business? Should business side be included from day 1 or how it should work internally?
- How do you see external players? For instance, suppliers and complementary products?
- For a player X in a slow growing and saturated market now, what would be the best move in a strategic management of innovation, is it opening new market or exploring blue ocean?
- How large ICT companies can have SME innovative environment?
- What tools companies use to support innovation, tangible and non-tangible?
- Is there a role to the government? Is it major or just facilitator?
- Does financial situation affect innovation, in term of idea to market flow?



- Is there a framework for open innovation in your company? If yes, what is it, and if no, do you think it is useful to develop a clear process for it?
- Specific interviewee's questions
- Open discussion